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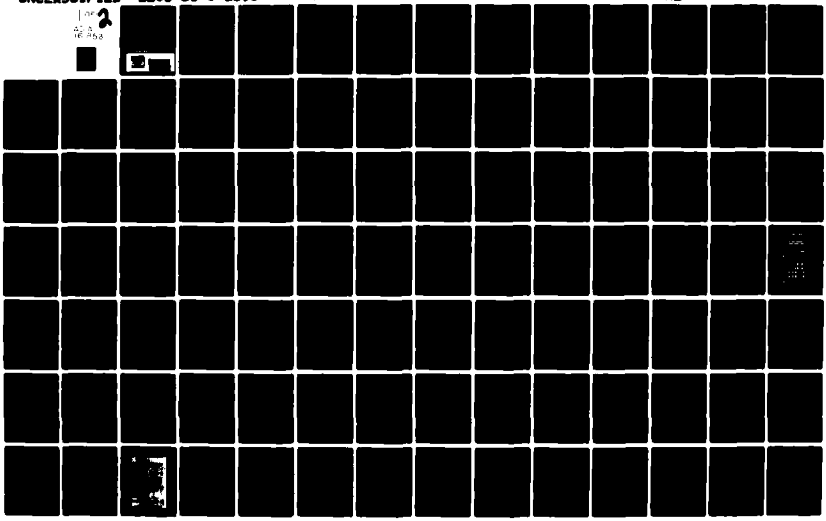

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FINAL REPORT

DEVELOPMENT OF AVIONICS INSTALLATION INTERFACE STANDARDS

December 1981

Prepared for
AERONAUTICAL SYSTEMS DIVISION
DEPUTY FOR DEVELOPMENT PLANNING (ASD/XR)
AND DEPUTY FOR AVIONICS CONTROL (ASD/AX)
WRIGHT-PATTERSON AIR FORCE BASE
DAYTON, OHIO 45433
under Contract F04606-79-G-0082-S706

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by

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FOREWORD

Under Contract F04606-79-G-0082, Delivery Order S706, ARINC Research Corporation prepared two strawman military standards that addressed the general requirements for the installation of avionics line replaceable units (LRUs) in the avionics bays and cockpits of military aircraft. A number of "open forum" discussions were held with airframe industry representatives, avionics industry representatives, development agencies, and logistic support personnel from the military services.

The strawman standards were based originally on the Airlines Electronic Engineering Committee (AEEC) ARINC Specifications 600 and 601, but these requirements were extensively modified to meet the structural and environmental characteristics of high-performance combat aircraft.

A Summary Report issued in June 1981 (and reissued in August 1981) provides a record of the preparatory work for the open forum held on 21 through 23 April 1981 and the working group recommendations and issues concerning avionics bay installations that resulted from that meeting. The material presented herein continues the record of those issues and recommendations through the second open forum held on 6 through 8 October 1981 and includes the results of working group reviews of the cockpit avionics installation standard.

ARINC Research Corporation acknowledges the valuable contributions to this study provided by the Aeronautical Systems Division engineering staff (ASD/EN) and the many aircraft and avionics industry representatives who attended and supported the open forum (as listed in Appendix A), as well as others, unable to attend, who provided written comments.

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CHAPTER ONE

INTRODUCTION

This report summarizes ARINC Research Corporation's efforts under Air Force Contract F04606-79-G-0082, Delivery Order S706, "Standard Rack-Mounted and Panel-Mounted Avionics Interface Concepts Analysis." The period of performance was 1 June 1981 through 31 December 1981.

The technical areas addressed were the analysis and specification of rack-mounted avionics, cockpit-mounted control panels, and panel-mounted instruments. Contract tasks included the following:

- Distribute the draft Packaging, Mounting, and Environment (PME) Standards and other "working papers" to our mailing list of interested and potential attendees at the open forum
- Arrange and conduct a second open forum
- Address issues remaining after the second open forum and develop work plans to resolve them
- Continue the development of the PME specification for high-density/ high-dissipation avionics packaging

1.1 TASKS AND TECHN[illegible]AL APPROACH

The tasks and accomplishments described in this report constitute a continuation of the effort funded under Air Force Contract F04606-79-G-0082 during the period 30 August 1980 through 15 June 1981. A summary report, *Development of Avionics Installation Interface Standards,* was issued in June 1981 (and reprinted with minor changes in August 1981); this report detailed the work performed, including the open forum meeting held in April 1981. Because of the continuing nature of the work, that report also contained material relevant to the tasks described herein. The report, together with other "working papers," was distributed to all our listed potential attendees prior to the second open forum. The following subsections describe the tasks of our current efforts and synopsize the results.

1.1.1 <u>Task 1: Refine and Distribute PME Standards</u>

We updated the Avionics Bay Installation Standard (MIL-STD-XXX) to include the recommendations of the first open forum and developed new strawman installation configurations addressing still unresolved issues. This work was completed early enough to be included in the summary report of June 1981. We also distributed the updated Standard as a working paper for the second open forum and subsequently updated it further with the changes developed at the second open forum. The latest updated version is provided as an Attachment to this report.

Since it was not addressed at the first open forum, the strawman Air Force Control and Display Unit Installation Standard (MIL-STD-YYY) was included, unchanged, in the June 1981 summary report. This draft standard was later updated with respect to common requirements that could logically be read across from the draft MIL-STD-XXX. The updated MIL-STD-YYY was then distributed as a working paper for the second open forum.

1.1.2 Task 2: Conduct Second Government/Industry PME Open Forum

We provided the necessary technical materials, engineering resources, arrangements, invitations, host facilities, and secretarial support, and conducted a second PME open forum meeting. The forum took place 6 through 9 October 1981. After the forum, we prepared the proceedings and notes, which are included herein. In addition, we revised the PME specification (MIL-STD-XXX) to include findings from the open forum meeting.

1.1.3 Task 3: Evaluate PME Issues and Develop Work Plans

We defined those issues which required further analyses, studies, and tests before the Air Force could reach a decision affecting the PME specifications. For each issue, we provided planning recommendations on the needed work.

1.1.4 Task 4: Continue Development of PME Specification for High-Density/High-Dissipation Avionics Packaging

We prepared and distributed as a working paper a strawman draft addendum addressing the accommodation of high-power-density/high-dissipation LRUs, either in a standard LRU form factor in association with other LRUs or mounted independently.

1.2 REPORT ORGANIZATION

This report is organized chronologically to facilitate understanding the relationship between the two open forums and our activities in support of the forums. Chapter Two provides information on significant issues that resulted from the first open forum. Chapter Three describes our activities between the two forums, particularly with respect to MIL-STD-XXX. Preparations for and the results of the second open forum are presented in Chapter Four. Chapter Five reviews the issues that remained unresolved after the forum was completed. This chapter also presents our evaluation of the issues and our recommendations for resolving them. Chapter Six examines the overall process of approving the standards, the steps that should be taken for successfully completing that process, and events to be considered in selecting candidate aircraft and equipments to implement the new standards. Conclusions and recommendations resulting from our efforts are provided in Chapter Seven. Supporting appendixes and an Attachment are also provided:

- Appendix A: Second Open Forum - List of Attendees
- Appendix B: Testing Laboratory Report on Preliminary Structural Tests
- Appendix C: MIL-STD-XXX Documentation
    - List of Change Requests
    - List of Changes Made
- Appendix D: MIL-STD-YYY Documentation - List of Changes Recommended
- Appendix E: Strawman Addendum to MIL-STD-XXX
- Attachment: Draft Air Force Avionics Installation Standard, 15 December 1981

CHAPTER TWO

SIGNIFICANT ISSUES REMAINING FROM FIRST OPEN FORUM

The results of the first open forum were included in our June 1981 Summary Report, *Development of Avionics Installation Interface Standards*. Because the first forum provided material for the second, this chapter describes significant issues developed during the first forum and the preliminary industry and government discussions that preceded it. The following sections list these issues briefly and describe them as they were understood at the conclusion of the forum. Changes that were made to MIL-STD-XXX are also described. Since the strawman Air Force Control and Display Unit Installation Standard (MIL-STD-YYY) was not discussed at the first forum, the issues discussed in this chapter all pertain to avionics bay installation issues and MIL-STD-XXX.

2.1 HEIGHT OF LRU AND CONNECTOR

The open forum resolution was to retain the heights contained in ARINC-600. This resolution arose from the need to accommodate the wide range of established components, modules, and circuit board assemblies that have been developed and qualified by industry. The associated investment in production tooling was also considered in this resolution. The heights (in inches) are:

Source	LRU	Connector
ARINC-600	7.625	6.96 (3 inserts)
Air Force Suggestion	6.00	5.42 (2 inserts)
Open Forum Resolution (draft MIL-STD-XXX)	7.625	6.96 (3 inserts)

2.2 CHOICE OF CONNECTOR

Although there was concern over the suitability of "blind mating rear-mounted rack and panel connectors" for general military avionics applications, the ARINC-600 series of connectors was selected as the standard for PME LRUs and racks because it exhibits many improvements over current rectangular connectors.

2.3 EMI/EMP SHIELDING

The need for EMI/EMP shielding to meet increasingly strict military criteria was noted in both industry and government comments, and was further emphasized at the open forum; however, no specific design requirements could be stated. In addition, significant problems now being experienced in requalifying existing MIL-SPEC connectors indicated the need for caution in specifying design criteria.

2.4 RACK CONNECTOR ACCESSIBILITY

The rack connector must be removable from the front of the installed rack. Access from behind is impossible in many types of military aircraft. This need, together with the EMI/EMP shielding issue, suggested that the connector plug shell would have to be reconfigured.

2.5 COOLING-AIR CONFIGURATION

The ARINC-600 cooling-air configuration was discarded for three reasons: (1) to preclude the direct impingement of cooling air on the electronic components, (2) to allow the free exhaust of cooling air into the compartment, and (3) to relocate the cooling-air inlet aperture(s) to the rear face of the LRU. There was concern about how well the backplate cooling air and connector locations could be simultaneously accommodated.

2.6 COOLING-AIR PARAMETERS

The ARINC-600 cooling-air parameters were discarded for two reasons: (1) to preclude the direct impingement of cooling air on the electronic components, and (2) to minimize the possible demands on the aircraft environmental control system (ECS). The military characteristic curve for the cooling-air flow requirement is based on a normal exhaust-air temperature of 71°C (160°F). Current ECS specifications provide for a normal entry temperature of 15.5°C (60°F). The cooling-air static pressure drop through the LRU should be standardized at 2 inches water gauge.

2.7 LRU DESIGN REQUIREMENTS

A need for a more consistent approach to LRU design requirements was voiced at the first open forum. The major points emphasized are described below.

2.7.1 Weight and Power-Dissipation Limits

Future military avionics were seen to be more densely packaged and heavier than allowed for in ARINC-600; they would also dissipate more heat.

High-speed digital processors were cited as examples. The weight limits (Table II) were raised 50 percent and not cut off at the 44-pound (20 kg) upper limit. Power-dissipation limits (Table III) "with cooling air" were increased fivefold.

2.7.2 Environmental Conditions

The following environmental conditions were established:

- Ambient Temperatures

  -62°C to 95°C, ground survival
  -40°C to 85°C, 30 minutes operating
  -15°C to 71°C, continuous operating

- Temperature/Altitude

  71°C continuous, 95°C short term at sea level
  10°C continuous, 35°C short term at 70,000 feet
  (following MIL-E-5400T: Class 2)

- Vibration, 0.04 g^2/Hz, 15 to 1,000 Hz, 6 dB roll-off to 2,000 Hz
- Acceleration, horizontal ±6.1 g, up 4.1 g, down 10.4 g
- Shock (crash), horizontal ±9.15 g, up 15.6 g, down 6.15 g

2.7.3 Cooling Evaluation and Electronic Part Application

Analysis and test should be structured to demonstrate the following:

- Low-power and integrated-circuit junction temperature will not normally exceed 105°C, power devices 125°C.
- LRU sidewall temperature will not exceed 71°C average, 80°C hot spot.

2.7.4 Reliability vs. Cooling-Air Flow

The thermal evaluation should address the effect of steady-state electronic part temperature changes on the calculated LRU reliability. These changes should be measured with both reduced and enhanced cooling-air flow rates relative to the standard air flow requirement.

2.8 STRENGTH OF REAR CONNECTOR SHELL

In view of the new concept of restraining the rear end of the LRU by the mated connector shells only, there were reservations about their ability to sustain the combined acceleration loads, shock, and vibration experienced in the military aircraft environment. No test data on these questions were available.

2.9 ELECTRICAL INTEGRITY OF CONNECTOR

In view of the low-insertion-force characteristics designed into the connector signal pin and socket combination (about 1/5th of current military practice), there were reservations about the ability to maintain continuity under vibration and shock conditions. Civil qualification tests originally did not consider interruptions shorter than 1 microsecond. No test results were available, other than the civil qualification test report.

2.10 MIL-STD-XXX UPDATE

Within the scope of the initial work effort (i.e., August 1980 to June 1981), the avionics installation standard was updated and included in the referenced Summary Report.

2.10.1 Changes Made

Following the open forum recommendations, these changes were made:

- The LRU height was restored to 7.625 inches.
- The ARINC-600 electrical connector was specified.
- EMI/EMP requirements were referenced to MIL-STD-461.
- Cooling-air apertures in the backplate of the LRU were illustrated.
- Cooling-air parameters were changed to be consistent with 71°C exhaust temperature and 2 inches water gauge static pressure drop.
- New weight-limit and power-limit tables were developed.
- New environmental conditions were specified.
- Analysis of the effect on reliability of less or more steady-state cooling-air flow was made a requirement.

2.10.2 Changes Considered but Not Made

The following three subjects were considered for change but, for reasons cited below, the changes were not made:

- Front-mounting the connector plug in the rack
- EMI/EMP provisions in the connector plug
- Direct specification of semiconductor junction-temperature limits

Attention to the first two subjects was withheld pending recommendations or proposals from industry (or specific requirements from government) on the changes from the ARINC-600 standard connector plug configuration needed to provide adequate EMI/EMP protection. It was considered that the third subject exceeded the scope of the interface standard and cooling system evaluation and should more properly be addressed in each individual LRU design specification.

2.10.3 Derivative Changes Suggested and Included

The following "strawman" changes were introduced as suggestions for resolving apparent conflicts or fulfilling expressed needs:

- Connector offset from LRU centerline to allow for cooling-aperture location on the rear of the smaller-size LRUs
- Tabulation of possible cooled/uncooled configurations by LRU size
- Illustration of traymount rack assembly
- Illustration of sideways mounting of the smaller-size LRUs to provide a low-profile configuration for individual mounting in restricted-height airframe bays

2.11 SUMMARY

This chapter has presented significant issues developed during the first open forum and changes made to MIL-STD-XXX.

At the first forum, agreement was reached on the following subjects:

- ARINC-600 box sizes (except 1 MCU)
- ARINC-600 rear-mounted connector (subject to military upgrading and retrofit constraints)
- "Military ECS" cooling regime
- Increased weight and power-density limits
- Combat aircraft environment (all aspects)

The following items were cited as unresolved issues:

- How to combine rear air inlet and rear connector
- How to serve present retrofit market

In addition to these unresolved issues, the following were cited as specific concerns:

- Mechanical adequacy of connector to support and restrain LRU under the specified acceleration loads, shock, and vibration
- Electrical integrity of connector in military environment

CHAPTER THREE

ACTIVITIES OCCURRING BETWEEN THE FIRST AND SECOND OPEN FORUMS

This chapter describes the activities undertaken on MIL-STD-XXX by ARINC Research Corporation during the interval between the first and second open forums. Preliminary findings of the first forum were described in Chapter Six of the June 1981 Summary Report previously cited. This chapter addresses the same subject areas and describes the work accomplished in preparation for the second forum. Comments resulting from discussions at the second forum are also provided.

3.1 UPDATING OF THE STRAWMAN STANDARD

3.1.1 High-Power/High-Dissipation Addendum to MIL-STD-XXX

Design considerations for five types of high-power avionics installations were reviewed, as described in Appendix C to the June 1981 Summary Report. A strawman addendum to MIL-STD-XXX was subsequently prepared and distributed with the working papers for the second open forum.

3.1.2 Accommodation of Cooling-Air Inlet

The strawman design prepared for the revised MIL-STD-XXX was illustrated. The size 1 ARINC-600 connector was reintroduced to provide more area for cooling-air inlets in small LRUs. At the second open forum the strawman stimulated discussion that resulted in the adoption of a more practical and more generally acceptable configuration. That configuration uses a reduced-height size 2 connector in place of the size 1 connector for the smaller LRUs (size 5 and below).

3.1.3 Accommodation of Orientational Flexibility

The concept of laying a small LRU (below size 5) on its side in an individual mounting tray was explored, and a strawman layout was provided. The connector was not really adaptable to this configuration, because its datum location moved from the base to the side (i.e., Datum B on the LRU is mated with Datum G on the tray, and Datum C on the LRU is mated with Datum K on the tray). However, the change noted above in Section 3.1.2 provides the opportunity to reconsider the small-size LRU connector-positioning tolerances and the datums to be selected.

3.1.4 Revised Vibration Requirement

The vibration requirement was originally intended to define a moderate vibration environment of 0.04 g^2/Hz, to be provided (at least as an objective) by the aircraft installation designer. The revised vibration spectrum (Figure 6-7 in the June 1981 Summary Report) should have extended the spectrum down to 15 Hz. The spectrum illustrated did roll off at 6 dB per octave between 1,000 and 2,000 Hz, although this slope was not annotated. The new figure (Figure 5 in the Attachment) now includes an endurance-test-level acceleration spectrum at 0.3 g^2/Hz, reintroduced by the second open forum.

3.1.5 Ambient Temperatures

The specified limits were revised in accordance with the recommendations of the first open forum.

3.1.6 Maximum Thermal Dissipation

The thermal-dissipation limit for each size of forced-air-cooled LRU was increased in accordance with the recommendations of the first open forum. That severe increase (by a factor of 5) was subsequently moderated to a factor of 2.5 by the second open forum.

3.1.7 Environmental Control System (ECS) Requirements for Cooling-Air-Mass Flow as a Function of Inlet Temperature

A chart was prepared to show the relationships between cooling-air flow rate and inlet and exhaust bulk air temperatures for a wide range of cooling regimes. The consensus of the second open forum was that too much information was presented, and a simple curve showing flow rate required vs. inlet bulk temperature was ultimately substituted.

3.1.8 Cooling-Air Humidity

The fault-condition maximum humidity (154 grains per pound of dry air) was included as recommended. This amounts to 0.023 pound per pound, or 23 grams per kilogram.

3.1.9 Cooling Evaluation Test

No action was taken in this area other than bringing the MIL-STD-XXX Appendix I test values and diagrams into conformity with the changes made to the design requirements and LRU configuration in the body of the specification. However, the second open forum later recommended what would be essentially a complete rewrite of this appendix.

3.1.10 LRU Hot Spots

The average sidewall temperature limits of 71°C average and 80°C hot spot were specified. The second open forum subsequently deleted reference to hot spots.

3.1.11 Weight Limits for LRUs

The weight limit for each LRU size was increased 50 percent or more. The size 2 limit was doubled, corresponding to a density of 0.1 $lb/in.^3$; the size 12 limit was also doubled; this corresponds to a density of 0.06 $lb/in.^3$. Other sizes were proportionately scaled in between these extremes. Following the recommendation of the second open forum, the smaller LRU weight limits were subsequently brought into conformance with the 0.06 $lb/in.^3$ density figure.

3.1.12 LRU Holddown Device

No changes were made in this area.

3.1.13 Electromagnetic Compatibility and Electrical Bonding

This subject remained an unresolved issue. Requirements will be included when a PME connector Military Specification is developed. This action was recommended again by the second open forum working group. It was also apparent that the method of electrical bonding between the LRU and the airframe, either directly or through the rack or tray, was an issue and that guidance with respect to a preferred or acceptable bonding means was lacking.

3.2 TESTING ON THE ARINC-600 CONNECTOR

3.2.1 Connector Strength and Attachment

Although mechanical strength requirements are specified for the ARINC-600 connector, the civil qualification test* addressed shock and vibration testing only. The tests were performed on isolated connector pairs, i.e., not installed in a representative rack and LRU. The qualification test levels were 50 g half-sine-wave shock, three times in each of six mutually perpendicular and opposing directions (18 total shocks, per MIL-STD-1344, Method 2004.1, Test Condition A); and 0.2 g^2/Hz random frequency vibration between 100 Hz and 1,000 Hz with 6 dB per octave roll-off at each end of the spectrum, to the test limit frequencies of 50 Hz and 2,000 Hz (i.e., MIL-STD-1344 Test Condition V, Level E), eight hours, in each of three mutually perpendicular axes.

3.2.2 Connector Mechanical Load Testing

In addition to the MIL-STD-XXX activities described in Section 3.1, we investigated the criticality of connector mechanical strength. We performed preliminary load testing, using representative production standard

*Boeing Commercial Airframe Company Document T6-6294, *Qualification Tests of ARINC-600 Low Insertion Force Connector,* 2 April 1979.

connector shells (provided by ITT Cannon), modified production mounting trays (provided by Hollingsead International), and dummy LRU load test assemblies fabricated by ARINC Research Corporation. This testing is detailed in Appendix B.

3.2.3 Test Objectives

It was intended to verify, by means of strain vs. stress relationships measured under static load conditions, whether the limits of elastic, or at least nondivergent, deformation of the tray/connector/dummy LRU assembly exceed:

1. The specified acceleration load limits for the maximum weight allowed for the LRU size represented
2. The specified crash-load (no breakaway) acceleration limits (these are 50 percent in excess of the limits of objective 1 above)
3. Equivalent calculated load limits representing the connector's mechanical stress when it is supporting the maximum-size LRU at its maximum allowed weight

3.2.4 Test Progress

Testing to achieve objectives 1 and 2 above was undertaken for a size 6 LRU in its normal upright orientation. There is also a design requirement for the ARINC-600 connectors to withstand a 1,000-pound compression load. This represents the force of a heavy unit being slammed into its tray and being stopped by the connector.

Table 3-1 summarizes the test results. As noted for test number 2, the plug fractured just before a 520-pound load was reached. This was well below the 1,000-pound compression-load requirement. The connector plug was reinforced and testing continued. As noted for test number 8, again just before a 520-pound load was reached, this time the receptacle fractured. Testing was discontinued pending a review of the method of assembling the connector shells into the tray and LRU. The review, to be accomplished in a subsequent effort, will also include consideration of connector configuration changes.

3.3 SUMMARY

This chapter has described the activities undertaken between the first and second forums, particularly in the MIL-STD-XXX subject areas discussed in the first forum and reported on in a preliminary manner in our June 1981 Summary Report. In addition, summary results of connector mechanical load testing have been presented.

Table 3-1. ACCELERATION-LOAD TEST RESULTS						
Test Number and Direction	Cycle	Applied Load (Pounds)	Deflection (Inches)	Incremental Set (Inches)	Total Set (Inches)	Estimated Mechanical Hysteresis (Inches)
1. Downward	1	1,000	.054	.010	.010	---
2. Into Tray	1	500	.110	Plug fractured just before 520-pound load was reached.		
3. Left Side	1 2	320 320	.068 .069	.018 .002	--- .020	 .012
4. Upward	1 2 3	220 220 320	.077 .084 .123	.004 .001 .009	--- .005 .014	.023 .012 .026
5. Out of Tray	1 2	320 220	.111 .084	.003 -.001	--- .002	.040 .025
6. Right Side	1 2	320 220	.051 .041	.008 0	--- .008	.006 .006
7. Downward	1 2	320 220	.036 .030	.008 0	--- .008	.002 .004
8. Into Tray	1	500	.063	Receptable fractured just before 520-pound load was reached.		

CHAPTER FOUR

THE SECOND OPEN FORUM

4.1 PREPARATION

The Second USAF Installation Standards Forum was scheduled for the week of 5 October 1981, to avoid conflict with the USAF Armament and Avionics Planning Conference (21-25 September) and the U.S. Navy Crew Station Design Symposium (15-16 September). A planning meeting was held with ASD/XR and ASD/EN at Dayton on 10 and 11 September to review and finalize the open forum arrangements and working group structure.

4.1.1 Invitation

The Air Force provided a letter of invitation to the second open forum. ARINC Research distributed the letter, together with the agenda and other working papers, to the government/industry distribution list in the week of 17 August.

4.1.2 Working Papers

The documentation sent with the letter of invitation included:

- Agenda
- Acceptance/clearance form and hotel information
- Summary Report* (to those not already on the report distribution)
- Draft MIL-STD-XXX
- Strawman MIL-STD-YYY
- Strawman High-Power-Density Addendum for MIL-STD-XXX
- Strawman Military Addendum for ARINC Specification 600

***Development of Avionics Installation Interface Standards*, ARINC Research Publication 2258-03-2-2477, June 1981.

4.1.3 Open Forum Structure and Working Group Organization

The structure of the open forum was not significantly changed from that of the April meeting. General sessions were held on the morning of the first and third days to brief the attendees on the agenda and objectives (day 1) and on the results and recommendations (day 3). During the intervening time, working groups reviewed the working papers, discussed issues, and developed recommended changes.

4.1.3.1 Agenda and Objectives

The published agenda is reproduced in Figure 4-1. The objectives of the open forum are listed in Section 4.2.1.3.

Tuesday, October 6	Wednesday, October 7	Thursday, October 8
Holiday Inn – Johnson Room 9:00 a.m. – 12:00 Noon General Session Introductions Scope Objectives Working Group Charters Issues Summary 2:00 p.m. – 5:00 p.m. Joint Session Planning Group MIL-STD-XXX Group **ARINC Building #1** 2:00 p.m. – 5:00 p.m. Joint Session CDU Cooling Group Multifunction Display Group	**ARINC Building #1** 8:30 a.m. – 5:00 p.m. Working Groups 1. MIL-STD-XXX 2. Multifunction Displays 3. CDU Cooling 4. Planning	**Holiday Inn – Johnson Room** 9:00 a.m. – 4:30 p.m. General Session Reports from Working Groups MIL-STD-XXX Progress Connector MIL-SPEC Issues Resolved Changes to be made Implementation Status High-Power Addendum CDU Standards Progress Form Factors Cooling Requirements Floor Discussion Summing Up

Figure 4-1. AGENDA: SECOND OPEN FORUM USAF AVIONICS INSTALLATION STANDARD

4.1.3.2 Working Group Organization

The working group structure was planned to focus attention on three different classes of avionics LRUs, each class having different characteristics and standardization needs as follows:

- Avionics bay and remote mounted LRUs. Work on the form, fit, and cooling standard is in progress (Draft MIL-STD-XXX).

- Crew station control panels (CDUs). These are well standardized to MS 25212 form and fit; their cooling requirements and interface definition are needed.
- Crew station multifunction displays (typically CRT units). Standard form, fit, and mounting methods need to be defined.

The Planning Group led the general sessions and also met independently to address administrative, procedural, and general implementation issues. As it turned out, the MIL-STD-XXX Working Group extended the scope of the interface standard to include general avionics design requirements, the two crew-station-oriented working groups combined in a joint review of the strawman MIL-STD-YYY, and subgroups on environmental and connector specifications evolved. Their proceedings are reported in Section 4.2.

4.2 PROCEEDINGS OF THE SECOND PME OPEN FORUM

ARINC Research Corporation hosted the second government/industry PME open forum meeting from 6 though 9 October 1981 at Annapolis, Maryland. This forum consisted of an opening general session on 6 October 1981, individual working group meetings from 6 through 8 October 1981, and a closing general session on 8 October 1981 to present the consensus reached. The Air Force working group chairmen reviewed the minutes, results, and consensuses, and recommended changes to the strawman standards on 9 October 1981.

4.2.1 Opening General Session, 6 October 1981

The ARINC Research program manager reviewed the agenda for the general session and introduced the first speaker.

4.2.1.1 Opening Remarks

The OSD representative welcomed the government and industry attendees. He emphasized the importance of industry participation in developing PME standards and applying them in the design of new airframes and avionics. OSD is very interested in this program as one of the improvements in the acquisition process called for in the Carlucci directives. These directives call for commonality, and the open forum is part of that activity. Carrying this activity to a successful conclusion will require the cooperation of government organizations and corporate managements.

4.2.1.2 ASD/XRS Review of Status and Progress on the PME Program

The USAF Program Manager for the PME project presented a briefing on the scope, objectives, and status of the program, as well as the progress made. He reviewed the rationale that was applied at the first open forum to arrive at the draft standards under consideration, which were substantially revised from the original strawmen. He presented the probable scenario for applying the standards to a mixed group of aircraft types and avionics functions. In particular, a basic new military standard, referred to as MIL-STD-XXX, is needed to apply to general military avionics such as communications and navigation equipments. An addendum is also needed to cover high-heat-dissipation LRUs such as radars and electronic warfare (EW) equipments. The existing ARINC-600 specification can be applied for the use of commercial avionics in military transport aircraft, subject to development of an addendum to articulate the additional testing requirements imposed by the more severe environment in the military transport aircraft.

4.2.1.3 Objectives, Structure, and Expected Results

The ASD/XRE representative outlined the procedures to be followed for the remainder of the forum and presented the objectives of the second open forum, shown in Figure 4-2. He described the working group structure, shown in Figure 4-3, and introduced the working group chairman. The goals of the forum were set forth as follows:

- A draft military avionics bay PME standard, referred to as MIL-STD-XXX, ready to be submitted for formal service coordination.
- Enough material to begin a military specification for the electrical connector for the avionics enclosure and rack.
- Military testing addendum to ARINC-600, ready to be submitted for AEEC approval.
- A draft high-power addendum to the military avionics bay standard, MIL-STD-XXX.
- A draft cockpit display and CDU standard, referred to as MIL-STD-YYY. This standard will apply to multifunction display and panel-mounted CDU and instrument cooling and environment. It also applies to multifunction display form and fit.
- An understanding of the implementation issues for all of the above.

4.2.1.4 Technical Issues

The ARINC Research project engineer presented suggested resolutions of the technical issues raised during the first open forum. He pointed out that these were only strawman changes to the draft standard included in the June 1981 ARINC Research report (Publication 2258-03-2-2477) soliciting the views of the participants.

Since control panel and instrument sizes have been fairly well established by current military standards, the basic issues were whether or not cooling air should be supplied to them, what their cooling-air interface should be, and how much cooling air should be provided. Issues to be resolved for multifunction displays were sizes of display area, cooling-air interface, mounting methods, and overall dimensions.

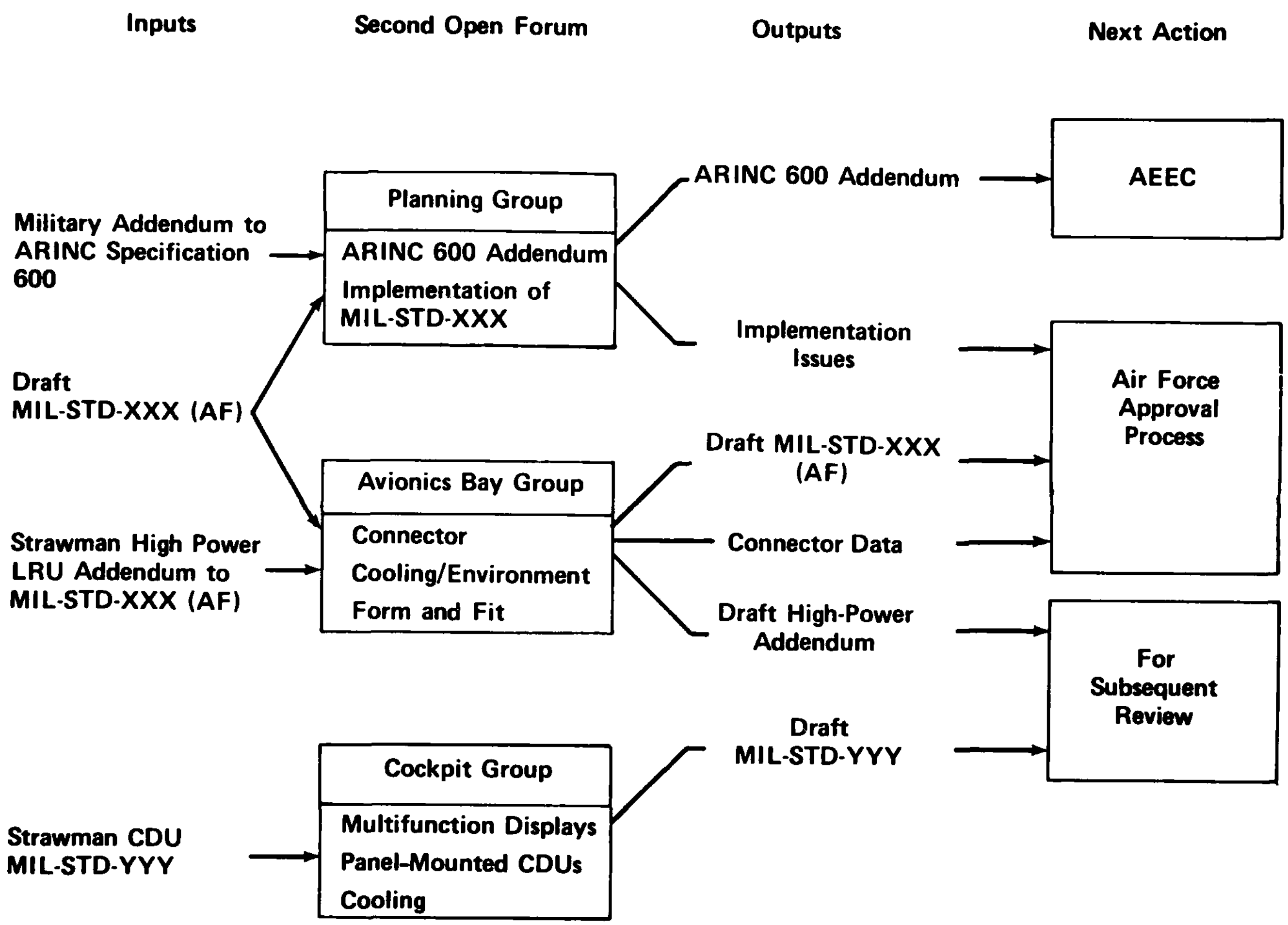

Figure 4-2. OBJECTIVES OF THE SECOND OPEN FORUM

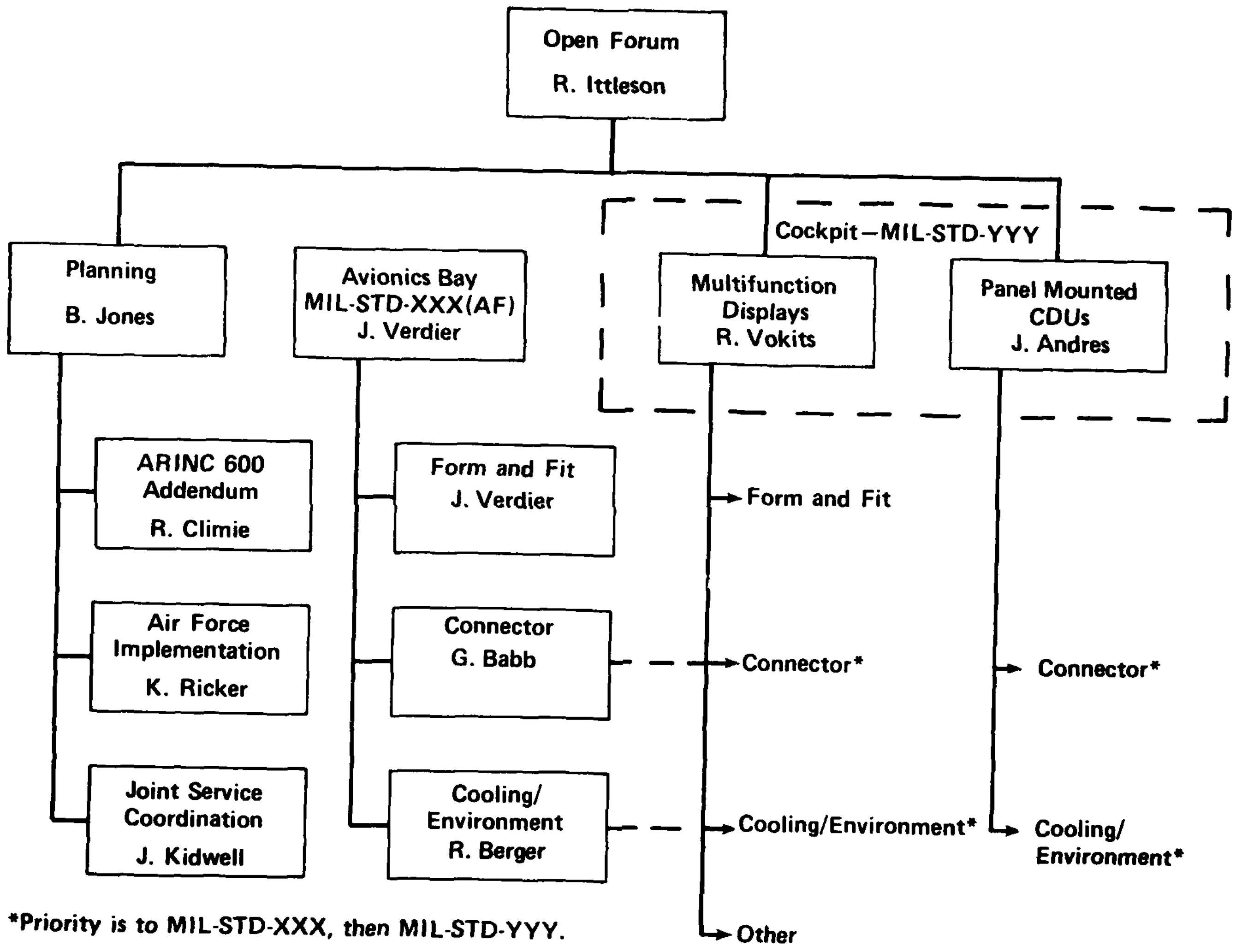

Figure 4-3. WORKING GROUP ORGANIZATION

Implementation steps for both standards might be identification of potential aircraft programs, briefing of the status of each standard to the Air Staff, determination of CFE/GFE candidate avionics subsystems for the selected aircraft, and Air Staff direction to the program managers.

The OSD representative commented that implementation issues should include OSD guidance to the military departments.

4.2.1.5 Navy Modular Avionics Packaging (MAP) Program

The Naval Avionics Center (NAC) presented an overview of the Modular Avionics Packaging (MAP) Program and its relevance to the USAF PME Program. They also thanked the Air Force and participating manufacturers for the cooperation that prevailed in the joint standardization efforts. In both services there is an operational need for less costly avionics (i.e., lower life-cycle costs) with better reliability and maintainability. The Navy's MAP Program involves a family of Standard Avionics Modules (SAMs) to be housed in standard avionics enclosures or integrated racks. Boeing has conducted a design and cooling-effectiveness study on standard enclosures for NAC.

4.2.1.6 Boeing Cooling-Effectiveness Study

A Boeing Aerospace Company representative presented a working paper on a cooling-effectiveness study of standard avionics enclosures being performed for NAC under Contract N00163-81-C-0011. Hollingsead International and ITT Cannon contributed hardware for this study. A copy of the material presented was distributed to the open forum attendees.

The objective of the study was to develop modular forced-air-cooled avionics enclosures, with ARINC-600 form factors, that can accept three standard module types: (1) conduction-cooled, (2) flow-through-cooled, and (3) heat-pipe-cooled. The cooling air should have an exit temperature of lower than 71°C while removing 250 watts from a 2-MCU-size box, 500 watts from 4 MCU, 750 watts from 6 MCU, and 1,000 watts from 8 MCU. (These are the same as the June 1981 strawman standard limits.) The cooling-air pressure drop was to be limited to 1.5 inches of water.

Computerized thermal/air-flow analyses showed that the pressure drop of 1.5 inches of water is the prime limitation in enclosure design. (The June 1981 Strawman Standard limited the pressure drop to 2 inches water.) Cooling methods for the 2-MCU-size enclosure are more restrictive than for the 4-MCU-size enclosure, and 250 watts' dissipation cannot be satisfied at 85°C junction temperature. For the 2-MCU 250-watt case, a junction temperature of 95 to 97°C must be allowed for the heat-pipe modules, and more than 105°C for the conduction-cooled modules.

Life-cycle-cost (LCC) analysis and structural analysis of four types of box assemblies resulted in a recommendation to use a bolted enclosure frame with removable guide rails as the standard design rather than a die-cast case design.

A survey of avionics enclosure heights on the F-14, F-18, and S-3A aircraft showed that the peak of the distribution for forced-air-cooled avionics occurs at the ARINC-600 standard height. The survey also confirmed that there was a wide variety of electrical connector positions and LRU mounting methods.

Boeing recommended a reduced-height low-insertion-force (LIF) connector "Type 2A" for the 2-MCU box. The reduced-height connector has one 150-signal pin insert and one power insert; this allows room for air inlets at the top and bottom of the LRU backplate, minimizing the cooling-air pressure drop.

Boeing displayed photographs and a demonstration model of the results of their design.

4.2.1.7 Open Discussion Following the Boeing Paper

NAC made the observation that apparently the Navy and Air Force standardization paths are converging. The minimization of pressure drop is important; NAC set the 1.5 inches water pressure drop as a challenge to Boeing. The fallback position was to permit 2 inches water, as specified in the June 1981 strawman.

ASD/ENASA noted that an ASD report written by Boeing is available: this is AFWAL TR 80-30-3148, Integrated Thermal Avionics Design Functional Description, dated May 1981.

Hollingsead International is working on the connector-mounting design and the means for connector-mounting reinforcement. They offered company resources to work out all ideas on enclosure design.

The OSD representative commented that there is an Air Force Laboratory program to build a new-generation avionics suite and there should be Navy coordination on it. Col. Bob Rankin will be in charge of this program.

4.2.2 Combined Planning/MIL-STD-XXX Working Groups

A joint meeting of the Planning Working Group and the Avionics Bay Working Group was held on 6 October 1981.

4.2.2.1 Military Addendum to ARINC-600

Concern was expressed about the vibration requirements in the strawman addendum to ARINC-600, which may exclude existing commercial equipments. ARINC-600 specifies a family of vibration ranges (per RTCA DO 160) for four different areas, based on vibration studies performed by commercial suppliers. For regular military transport aircraft, ARINC-600 (as written) may suffice, without additional vibration requirements. This would avoid high costs in rework and redesign of commercial units. The objective is to recommend compromise vibration levels as guidance to commercial manufacturers in designing equipment for use in both commercial and military transport (and other) aircraft, benefiting both sides. The specified vibration must not be far from the true requirements of either the commercial or military sector.

The use of some commercially used electronic components, such as plastic encapsulated semiconductor devices, may not be acceptable in military aircraft equipment.

It was suggested that the grounding and bonding requirements be reexamined.

4.2.2.2 Avionics LRU Configuration (MIL-STD-XXX)

There were concerns about the general LRU configuration now shown in the strawman (draft) MIL-STD-XXX:

- Off-centered connectors would lead to asymmetric loading on the connectors.
- Test results suggest that more buildup of the rack is required to prevent connector breakage. The specification should provide guidance as to where this buildup can take place.
- An opinion was expressed that the LRU weight limits in Table II, page 7, were too high and should be reduced.

There is a genuine need to specify an optional front connector configuration for retrofit purposes.

There was some doubt about the connector-to-rack alignment requirements, the adequacy of the dimensioning shown, whether such alignment is feasible in the "low profile" configuration proposed, and whether the provision suggested for the side-mounted holddown hooks should be mandatory or optional for small boxes.

Detailed review of these points was subsequently taken up by the Form and Fit Working Group (see Section 4.2.7).

4.2.2.3 Connector MIL-Specification

Emphasis was placed on the need to start "MIL-SPEC" action on the chosen connector; otherwise no connector hardware would be available to industry to produce MIL-STD-XXX LRUs and racks. Concerns were voiced again about using the connector as the only rear holddown, lack of EMI/EMP protection in the present (commercial) design, and circuit integrity of the "low insertion force" contacts for serial digital data in a high-vibration or shock environment.

Connector-related matters were subsequently discussed in more detail by the Connector Subgroup (see Section 4.2.8).

4.2.2.4 Environmental Design Requirements

Several of the environmental requirements in (or omitted from) the strawman standards were discussed. A suggestion to delete the environmental sections and reference MIL-E-5400 received some support, but the consensus was to provide specific environmental design guidance in these installation (or interface) standards.

Junction-temperature limits of semiconductor devices should be clearly stated in the electronic part application section of the standards rather than in the general discussion.

Vibration test requirements should be imposed on the rack as well as on the LRU.

Detailed discussions of these topics were subsequently taken up in the Environmental Standards Working Group (see Section 4.2.5).

4.2.2.5 Summary

The remaining major issues and concerns regarding the development of MIL-STD-XXX were summarized as follows:

- The philosophy of the standard should be to serve as an interface document and to provide guidance for the installation design, while the design requirements for the individual functional LRUs are covered in separate specifications. The question remains as to which particular design features and requirements should be also covered in MIL-STD-XXX.
- The design specified in the strawman has not been validated by test data, nor has a test program for the installation interface hardware, such as connectors, racks, and LRU cases, been developed. Specific areas of concern are:
    - Weight limits in the strawman may represent excessive loads on the connector.
    - Vibration loads on the connector may cause short-duration open circuits, degrading particularly the new, high-speed digital equipments.
    - The electromagnetic interference (EMI) properties have not been tested, and it is not known how to obtain additional EMI protection.
- Consideration should be given to adding requirements for sinusoidal vibration, over and above the random vibration.
- The use of commentary is helpful, but it is not normal practice for military standards. Perhaps it is necessary to issue a supplementary guidance document.

- The group appeared about evenly split between the philosophy that the physical interface cooling, mounting, and electrical connector requirements can be specified without regard to the LRU internal design, and the philosophy that the LRU design must be controlled in order to specify the effectiveness of the overall cooling system performance.

4.2.3 Steering Group Caucus

After the conclusion of the working group meeting, the steering group caucus agreed on the following guidelines:

- MIL-STD-XXX should serve as an interface standard rather than as an overall installation standard.
- The philosophy of the basic document is to describe those parameters which will assure that the interface between the LRU and the aircraft structure is sufficiently described in terms of cooling effectiveness, attachment points, and connector placement to enable equipments conforming to this standard to be installed in the aircraft without modification of the aircraft structure.
- Supplementary information, possibly in the form of commentary, or in an appendix, will be developed to provide guidance representing military and industry views on critical thermal design requirements internal to the LRU.

4.2.4 Multifunction Displays and Control Panels and Instruments Working Groups

The working groups on Multifunction Displays and Control Panels and Instruments met jointly on 6 October and continued as a single working group on cockpit displays throughout the open forum. The strawman MIL-STD-YYY was reviewed for the first time. Changes to the strawman standard that were agreed on by this working group are listed in Appendix D. The working group recommended that the strawman not be updated and reissued until further study and consensus had been accomplished.

4.2.4.1 General Comments

It was suggested that commentary should be added to the "Scope" about the need for separate LRU specifications to clarify the role of the MIL-STD-YYY as being a general guideline on cockpit units. This would apply in particular to the dimensional requirements as being guidelines for normal design.

The available cockpit space often establishes the display dimensions, because there is no alternate space available.

It was noted that the Kaiser F-18 multifunction displays that were being used as illustrations in the working groups were also being utilized in the AV-8B.

Glareshield and sidepanel locations should be included in the standardization of interfaces, but Heads Up Display (HUD) installation requirements should be specifically excluded.

It is necessary to clarify that MIL-STD-YYY is intended to be an interface standard and not an equipment design standard, and that it applies to the design of the interface, not the CDU.

There was also discussion of the terms *Multi-Function Display* (MFD) and *Electronic Flight Instrument* (EFI).

4.2.4.2 Environmental Requirements

Environmental requirements should be consistent with MIL-STD-XXX. It was remarked that the vibration-endurance test level for equipment to be installed in the F-15 is being raised from 9.5 g rms (about 0.07 g^2/Hz) to 20 g rms (about 0.3 g^2/Hz). The B-52 requirement is 0.06 g^2/Hz for 36 hours.

4.2.4.3 Thermal Management

The group noted that the thermal-dissipation limit of 1 watt/in.^{3} (Table 1*) would work out to about the same power-dissipation limits as previously specified for the MIL-STD-XXX units (215 watts for 2 MCU, 466 for 4 MCU, and 964 for 8 MCU, compared with 250, 500, and 1,000 watts, respectively) but the MIL-STD-XXX figures are now being divided by two.

Surface-temperature limits should be checked against MIL-STD-1472 (Human Engineering Design) and MIL-E-87145 (Environmental Control Design).** Commentary about the basis for deriving the limits should be added. There is a problem in maintaining acceptable surface temperatures in a Class 2 environment.

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*Table I referred originally to MS 25212 console-mounted units and similar-size instruments. The largest MS 25212 unit is 5 × 9 × 6.5 inches: 292.5 in.^{3} volume, 272 in.^{2} surface area, giving (from Table I):

Type of Cooling	Surface Area Limit	Volume Limit
Forced-air cooling	N/A	292 watts
Flow-by cooling	41 watts	60 watts
Convection cooling	13.6 watts	N/A

**MIL-STD-1472 is silent on touch temperatures. MIL-E-87145, Appendix C, Tables 1-1 and 1-2, detail light-touch temperatures on metal surfaces as 45°C threshold of pain, 49°C for 15 seconds tolerance, with leather gloves 66°C for 13 seconds tolerance. MIL-E-87145, Appendix A, also points out that an average cockpit steady-state surface temperature above 40°C adds to the heat load perceived by the crew.

4.2.4.4 Cooling Needs

ECS design requirements and MIL-E-87145 should be studied further in conjunction with airframe manufacturers.

There was discussion of the need to be consistent with MIL-STD-XXX* with respect to all aspects of the cooling-air supply, including abnormal in-flight operation, loss of cooling air, and the requirements for coolant-air quality (e.g., moisture, dust). Direct air impingement should be generally prohibited in Type A cooling but permitted "when approved by the procuring activity."

4.2.4.5 Larger Integrated Display Units

The group confirmed the note on Figure 3 of MIL-STD-YYY that further review of the dimensions shown or tabulated was necessary. Other comments were as follows:

- The cooling-air system need not be a closed system. The F-18 has no room for rear air entry/exit.
- Fans (in LRUs) should be avoided.
- There should be a positive indication for each display to show that it is securely fastened in the rack.

4.2.4.6 Instruments Mounted on Instrument Panel

It would be appropriate to explain the rationale for basing Appendix II on the NATO STANAG 3319. This explanation could relate to an Air Force commitment to use that STANAG. No other comprehensive instrument standardization scheme was suggested. Appendix II should include reference to length limitations and preferred sizes and lengths.

4.2.4.7 Follow-Up Recommendations

There was discussion on follow-up MIL-STD-YYY activity that should take place. The ASD cochairmen thought that follow-up efforts should be controlled by an executive steering committee meeting monthly. Mr. Ron Vokits recommended that the following five items should be followed up within ASD:

- Survey of cathode ray tube (CRT) display sizes
- Survey of the connector types

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*Flow-through cooling accomplished strictly to MIL-STD-XXX exhausts air to the compartment at 71°C and allows average surface temperatures of 71°C. These features make that specification unacceptable for cockpit-mounted LRUs. The cockpit equipment cooling parameters must comply with "occupied compartment" standards, and the design should be fully compatible with the design of the cockpit temperature-control system.

- Evaluation of the installation methods
- Definitions of control display unit (CDU), multifunction display (MFD), and electronic flight instrument (EFI)
- Recommendations for new techniques in display installation, mounting, and cooling

It was agreed that manufacturers should undertake three action items:

- Analysis and recommendations for the relationships between size, weight, power, and cooling
- Recommendations for preferred STANAG standard instrument characteristics, such as size and form factor
- Analysis of overall cockpit cooling techniques

4.2.5 Environmental Standards Working Group

The Environmental Standards Working Group met on 7 and 8 October. Their discussions addressed issues that had been incompletely or incorrectly resolved by the changes made to MIL-STD-XXX after the first open forum. Appendix C of this report includes a listing of the further changes proposed, together with their dispositions.

4.2.5.1 Scope and Referenced Documents

The group's recommendation is to clarify the Scope paragraph to define form factor and cooling criteria for the LRUs and the equipment racks in the avionics bay, and to exclude cockpit equipment as well as pods, missiles, and high-power dissipation units. The environmental requirements should be individually stated in MIL-STD-XXX, but their basis should be MIL-E-5400. Test procedures should be referenced to MIL-STD-810.

4.2.5.2 Detailed Requirements for the LRU

The group preferred that the electrical connector remain on the center line and suggested that standardized, diagonally opposed cooling-air aperture locations (either one pair or two pairs) optionally serve either top/bottom heat exchangers or sidewall heat exchangers. A smaller (in height) connector would ease the cooling interface design problem for small LRUs, in which the diagonal cooling-air apertures would close up naturally into an upper/lower symmetrical configuration.

Cooling-air pressure-drop parameters should be specified more fully, and a leakage tolerance limit should be imposed for the LRU itself and for the aperture seal.

An LRU should be required to operate and survive through a 10-minute complete loss of cooling air, and also operate and survive through reversion to a cooling-air supply derived from ram air for 30 minutes. It is difficult, however, to provide a generalized definition of the characteristics of ram air cooling, because the characteristics vary with flight conditions and the system varies between aircraft types.

Vibration environment and vibration endurance-test levels should be specified by MIL-STD-XXX, extending upward in frequency from 15 Hz to 1,000 Hz and then rolling off at 6 dB per octave to 2,000 Hz. The environment level of 0.04 g^2/Hz was confirmed, but with required "commentary" that in some aircraft types excessive vibration would be unavoidable and, for those cases, equipment qualified to a higher vibration level would have to be provided. The LRU endurance-test level was subsequently fixed at 0.3 g^2/Hz (see Figure 4-4).

4.2.5.3 Detailed Requirements for the Equipment Rack

The cooling-air pressure drop attributable to the equipment rack should be subject to a specification limit by MIL-STD-XXX. What this limit should be was not decided.

4.2.5.4 Thermal Management

Thermal design and appraisal was the subject that received most attention from the working group. The ambient temperature specification was extended to -54°C and +95°C short term, +71°C continuous; and the thermal design condition was set at 71°C ambient, with cooling air supplied at either 15.5°C or 40°C at the appropriate flow rate. The short-term extremes of cooling-air temperature (one minute) should be -54°C to 71°C.

The equipment sidewall temperature should be referred to as "LRU surface temperature," and should not exceed 71°C average, with commentary that this is not a human factors requirement. This recommendation left unresolved the problem of convection cooling into 71°C ambient air.

There was extensive discussion about the LRU surface temperature versus the maximum thermal dissipation allowed by Table III. With the given surface-temperature limit of 71°C and a forced-air inlet temperature of 40°C, it is not possible to dissipate the wattage given in Table III for reasonable junction temperatures of 105°C. These wattage limits are some five times the values in the original strawman specification and should be reduced by a factor of two from the present strawman.

An opinion was expressed that there is too much detail in Appendix I. Test methods should be referenced from MIL-STD-810.

The sample should be tested early in the development program so that corrective changes can be introduced before the design is committed to production.

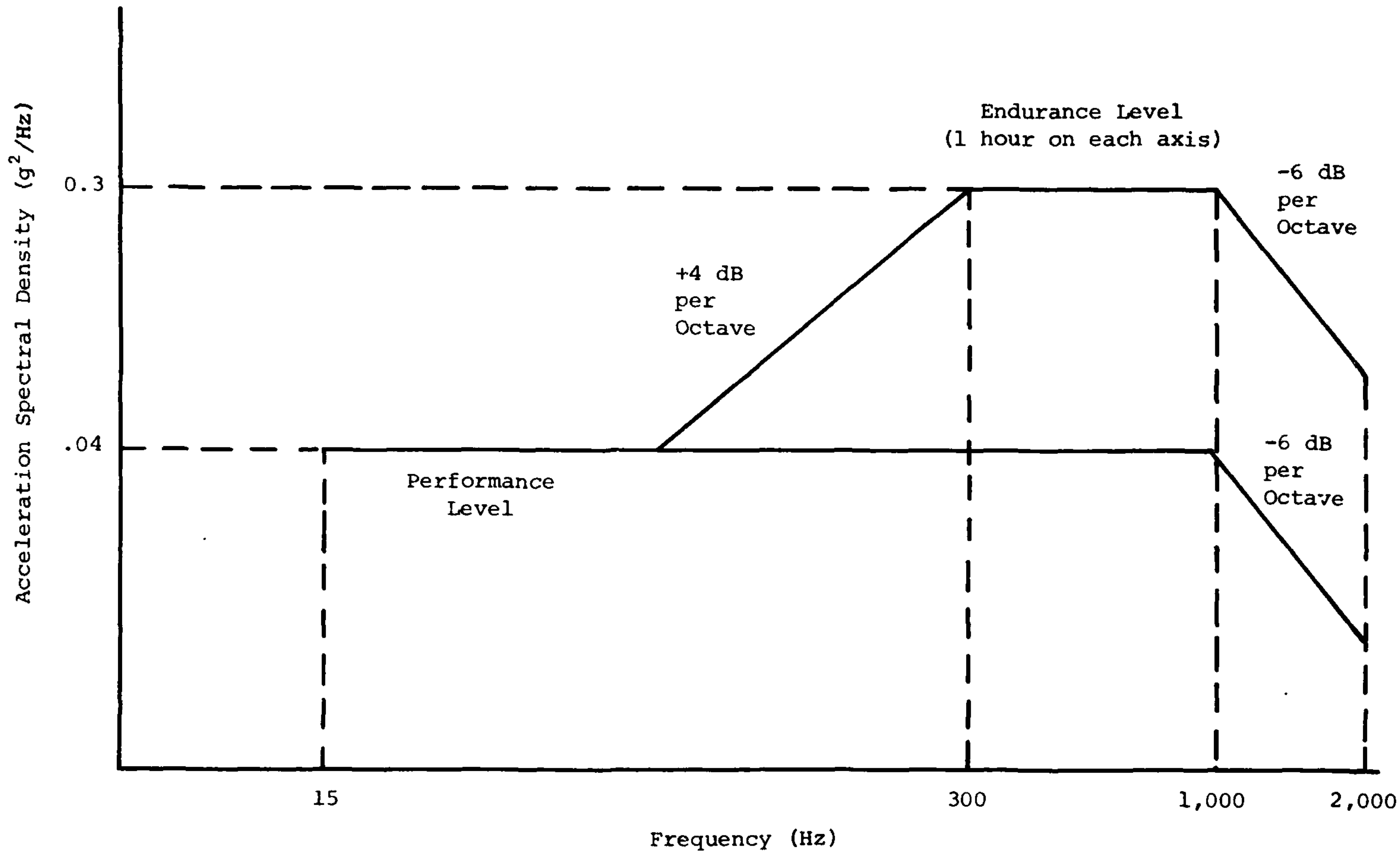


Figure 4-4. VIBRATION TEST REQUIREMENTS

4.2.6 Working Group on Military Addendum to ARINC Specification 600

4.2.6.1 Vibration, Shock, and Acceleration

Air Force personnel stated that the test to 0.04 g^2/Hz random vibration over the range of 20 to 1,000 Hz was intended to show whether or not the equipment would be generally suitable for military use, i.e., would withstand normal military handling, transportation, and servicing. The test was not related to meeting operational requirements in the aircraft. These requirements would be stated separately, as they are for civil equipment (see reference to RTCA DO 160 in ARINC Specification 600, Attachment 13).

After discussion, it was decided to modify the paragraph to make the foregoing clear. Figure 4-5 shows the vibration requirement.

4.2.6.2 Power Dissipation

The paragraph was modified to indicate that the power-dissipation values in ARINC Specification 600 are "never exceed" values for the LRUs listed. The actual dissipation is determined by the equipment designer using this guidance.

The use of the level 1 pressure drop (5 mm water gauge) was preferred, and the paragraph was modified accordingly.

4.2.6.3 The Equipment Rack

The wording of this paragraph was modified to indicate that while collection of the cooling-air exhaust from each rack shelf on military aircraft was not required, it was certainly not precluded.

4.2.6.4 Severe Humidity Environment

Discussion revealed that commercial equipment would find this condition difficult to meet. It was decided not to change the paragraph, however. Instead, the introductory paragraph to the addendum was revised to state that off-the-shelf commercial equipment might not meet all the requirements of the addendum and yet might be quite suitable for military use in some cases. These cases would be determined by the individual procurement activities. This caveat would apply to the whole addendum.

4.2.6.5 Use of Plastic-Encapsulated Components

The use of plastic-encapsulated semiconductors and other part-quality questions were reviewed. The conclusion reached was that no addition to the addendum was needed to cover this question since equipment warranties or other applied military specifications would address it adequately.

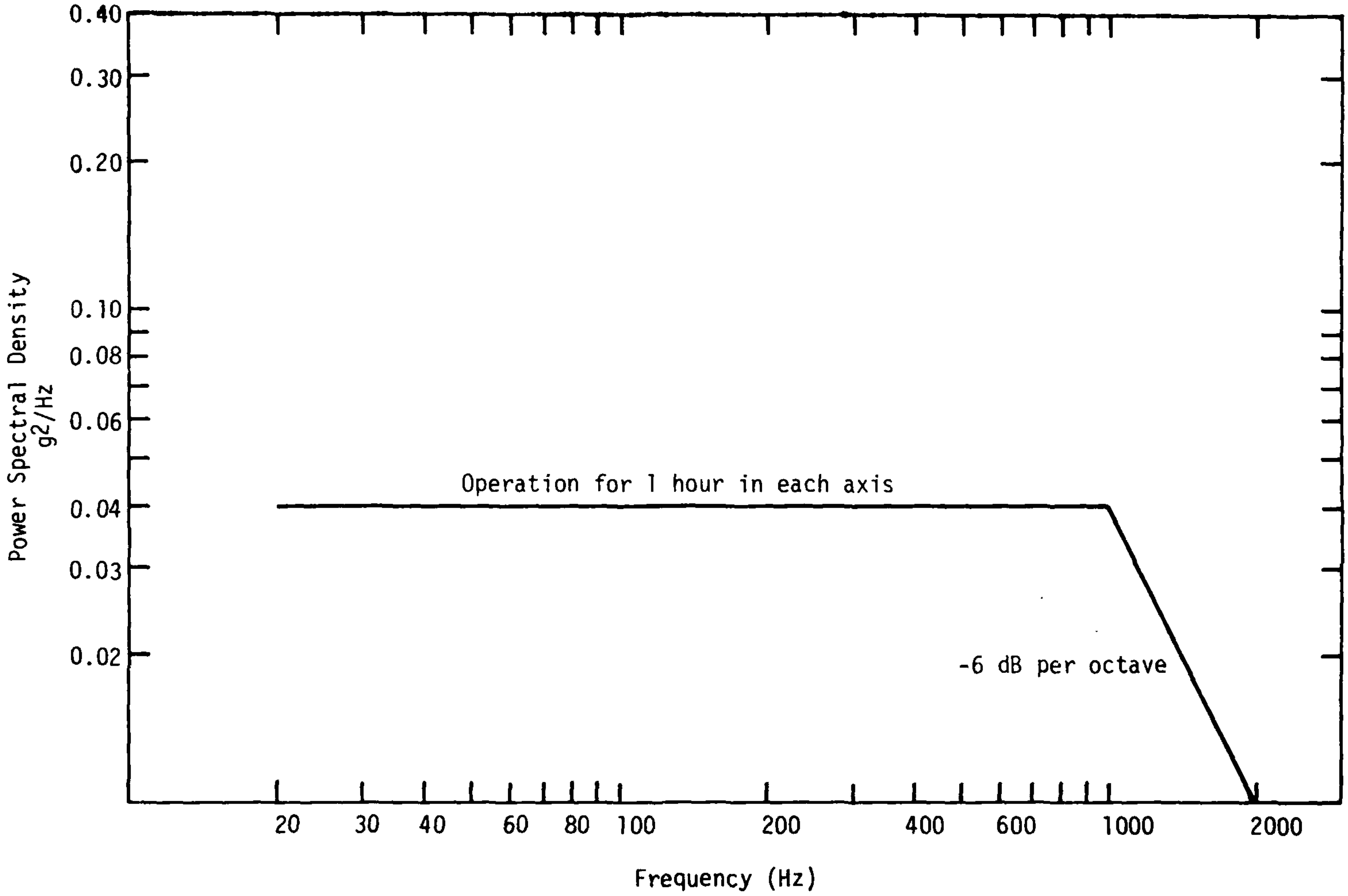


Figure 4-5. VIBRATION TEST LEVEL

4.2.6.6 Salt Spray Test

The need to specify a salt spray test for commercial equipment used by the military was reviewed. The conclusion reached (there was no military representation on the working group at the time) was that such a test was not needed, because of the design and manufacturing process routinely used to minimize the susceptibility of the equipment to corrosion.

4.2.7 Form/Fit Working Group

The Form/Fit Working Group met on 7 October 1981.

4.2.7.1 Discussions About Connector Requirements and Characteristics

Concern was expressed about the strength of the connector as a holddown device, particularly under dynamic loads of shock and vibration:

- The Boeing connector specification requires loads of 400 pounds up/down and side-to-side, and loads of 1,000 pounds fore/aft for all sizes of connectors.
- The worst-case Navy g-force requirements are for 21 g in the up direction and 12 g in the lateral direction. Dagger pins could be added in the box and in the rack to share the load, but dagger pins lead to a tolerance-buildup problem in the mating of the box and rack connectors.
- Dynamic analysis has been funded by the Air Force (to Boeing), but results were not available at the time of the open forum.

Another concern expressed was the lack of adequate space for wiring and cabling in the same area as cooling-air ducts. This problem is severe for small boxes.

Other areas of uncertainty regarding connectors are as follows:

- EMI/EMP test results, which may critically affect the connector design
- Sand and dust, fungus, humidity
- Contact continuity under dynamic loads

The question of permitting front connectors was raised. It was suggested that front connectors should be permitted as an option where the rear-mounted connector is not practical, mainly for retrofit installations. The group was asked if there was a consensus on permitting the front-mounted connector option. There appeared to be a preference for only rear-mounted connectors, with no option for front-mounted connectors.

There was a consensus that the asymmetrical location of the connector would be prohibited. The Environmental Standards/Cooling Working Group will define the location of the cooling intake/exhaust for each MCU size.

The consensus favors having all new aircraft installations employ the connector as the only holddown in the rear. For the retrofit installations not using the preferred rear-mounted connector, some other means of rear holddown must be provided. Specific words are needed to specify the rear holddown with front-mounted connectors.

4.2.7.2 Low-Profile Mounting

Another issue raised was the 90° reorientation of small LRUs to permit lower-profile mounting (height less than 7.62").

It was noted that the low-profile 90° orientation (side mounting) is applicable to 2-, 3-, 4-, or 5-MCU sizes only. The same tolerances should apply, and words are needed for this.

The consensus was that provisions for side holddown hooks (tapped holes and reinforcements) need to be provided on the left side only (viewed from front). Hooks are not to be installed until the 90° orientation option is actually employed.

4.2.7.3 Vibration and Cooling Discussion

The random vibration level is to remain at 0.04 g^2/Hz, as shown in the strawman. There should be a roll-off at a rate of 6 dB/octave above 1,000 Hz.

There was still a question about the operation of rack-mounted avionics with one LRU withdrawn. However, some designers stated that this should be no problem if the cooling system has been properly designed, and no plugs or valves should be needed.

It was noted that the environmental group has defined conditions and times for the loss of cooling air, including ram air operation. Thermal cut-out after the specified times is permitted, and there is no need to clarify thermal protection requirements.

4.2.7.4 Further Discussions About Connector

The Form/Fit Working Group received recommendations from the Environmental Standards Working Group regarding a revised, reduced-height connector. It was suggested that the proposed (ARINC-600) connector undergo several design changes and then be fully tested. The desired design changes are:

- Improvement in EMI/EMP protection
- Lower height
- Improved structural design to reduce stresses
- Reduced height in both single-width and double-width versions
- Front mounting capability

A question arose as to how the EMI filter could be mechanically integrated with the power input pins of the connector. Connector manufacturers will be asked for a solution.

ARINC Research presented the test results from the preliminary laboratory static load tests on an existing size 2 connector.

There was discussion of the Boeing analyses of the redesigned connector, size 2A. A size 3A could have 500 signal pins provided by two 150-pin inserts and two 100-pin inserts. Alternate arrangements are 450 pins with larger power pins, or 300 pins with additional coaxial pins. Fiber optic inserts similar to the current coaxial inserts have also been designed. The discussion suggested that it would be logical to extend the Boeing analysis efforts to include the testing of the revised connector, which would have to be supplied by separate arrangement with the manufacturers. The Air Force should consider funding this effort.

4.2.8 Connector Working Group

The Connector Working Group met on 7 October 1981 (splitting off from the Form/Fit Group).

The current ARINC-600 backshell is inadequate for military requirements. The flange will have to be modified to provide for a flat RF gasket and mounting screws. The current inserts will probably be used. In addition, it was thought that the current flange would not meet the full load and stress requirements (up to the 2,700 pounds). Cannon promised to inform ARINC Research of how the modified connector could be intermateable with the current, commercial connector. However, intermountability will not be achievable.

4.2.9 High-Power Addendum to MIL-STD-XXX Working Group

This working group met on 8 October. It reviewed the strawman that ARINC Research had prepared as a working paper for discussion and as a potential addendum to MIL-STD-XXX. A question was raised as to the purpose of including the numerous additional dimensional options in the strawman. More emphasis should be placed on keeping to the basic MIL-STD-XXX form factors.

The Westinghouse representative emphasized the reality of high-power-dissipation units, particularly high-speed signal processors but also high-power EW jammers. He said that representatives of the other manufacturers in those fields should be brought together so that their opinions could be taken into account in the proposed document. The need for guidelines on dealing with higher-power-dissipation LRUs gained more weight with the proposed reduction (by a factor of 2) in the maximum values of MIL-STD-XXX. The largest LRU can now dissipate 750 watts only. The strawman permits LRUs with higher dissipations to be installed in the MIL-STD-XXX rack assembly, if an engineering study shows that the higher-capacity air flow, or liquid coolant, can be provided without interfering with the operation of any of the standard LRUs installed; and if all other constraints are met.

The strawman high-dissipation addendum to MIL-STD-XXX is included as Appendix E to this report.

4.3 GENERAL SESSION CLOSING THE OPEN FORUM, 8 OCTOBER 1981

Dick Ittelson, ASD/XR, outlined the agenda for presenting the findings of the working groups.

4.3.1 Findings of Cockpit Display Working Group

The joint chairmen presented the findings of the combined Cockpit Display Working Group. The entire MIL-STD-YYY strawman had been reviewed by the group. Since MIL-STD-YYY is closely tied to MIL-STD-XXX development in environmental and cooling requirements, independent recommendations on common issues were deferred.

The strawman has used NATO STANAG 3319 for the size options, but this leaves too many options available for standardization, and a study of the preferred sizes is needed. A companion issue is the need for hard metrication since the document also covers NATO aircraft.

There were discussions of the scope of this document: should it cover individual units and instruments or the cockpit as a whole, and should it cover the transport cockpit environment or the fighter cockpit environment? It would be desirable to obtain the opinions of the fighter aircraft contractors.

The following issues, which will require further study before substantial progress can be made in the development of MIL-STD-YYY, were discussed:

- Connectors and the method of installation
- Multifunction display form and fit
- Standard instrument characteristics
- Environmental requirements
- Relationship to MIL-STD-XXX requirements
- Cooling techniques applicable to the cockpit
- Evaluation of the applicability and utility of MIL-E-87145

The following recommendations were agreed to by the group:

- The title should be changed to the Display and CDU Interface Standard.
- The Air Force-unique connotation should be deleted.

- ARINC documents should be used where applicable.
- The group included direct-air-impingement cooling as an available option.
- Commentary should be added where applicable, including the source of the requirements.
- Metric units should be added throughout.
- A range of standard unit sizes should be included.
- The MIL-STD-YYY draft should not be reissued without further study in the areas where further information is required.

There was a question from the floor about the sizing issue: Will the standard apply to instruments, as well as Cathode Ray Tube (CRT) displays, or is it assumed that CRTs will replace instruments? The answer was that the intention is to cover both CRTs and electromechanical devices. The latter will always be needed for standby purposes and are covered by the NATO STANAG.

Another question concerned whether it was worthwhile to pursue development of the standard and whether there would be users of the standard. The answer was that it was too early to tell if a cockpit would be designed to utilize standard units. The general opinion was that the design lessons learned would be helpful to the industry but that it would be up to the military to determine if the standard would be applied.

4.3.2 Findings of Environmental Standards Working Group

The chairmen of the Environmental Standards Working Group presented their results. The group continued to pursue the philosophy that this was a "super standard" (that still needs refinement) and it would be applied to the future, new avionics applications. There is a need for continued follow-up to track avionics installation developments.

The following major areas were addressed by the group:

- The connector should be centered for all sizes of LRU (for better heat-exchanger locations), leading to diagonal air inlets in general. For the smaller LRUs, a shorter connector is imposed by this configuration.
- The shape of the air inlets (square, circular, elliptical) was not specified.
- Maximum junction temperatures for all active semiconductor devices were recommended.
- The requirements for environmental criteria were developed for both LRUs and trays/racks. The connector requirements were not detailed, because a separate connector specification will be developed. The broad base used was the MIL-E-5400 environmental

requirements. The vibration environment for the LRU and tray was also treated in the recommendation. Cooling-air leakage limits of 2 percent for the LRU heat exchanger and 2 percent for the tray were assigned.

The main concerns of the working group were as follows:

- Review of the environmental compliance test requirements in Appendix I was not completed.
- Discussions of ram air operation, in case of ECS failure, were not fully pursued, particularly for the 95°C ambient conditions. The requirement for 10 minutes' operation without any cooling air needs further definitization.

There was a question from the floor as to the primary purpose of the LRU design guidance in the standard. The answer was that the LRUs would be covered by individual equipment specifications, but the standard provides a common basis for implementing the equipment specification requirements.

4.3.3 Findings of Form/Fit and Connector Working Group

The chairmen of the group briefed the findings of the Form, Fit, and Connector Combined Group.

A significant change from the previous draft was that only a centered connector was to be permitted. The rear-mounted connector remained as the primary standard. However, the standard also provided for the front-mounted connector for retrofit installation purposes.

The 90° mounting orientation is permitted for low-profile installations, applicable to size 5 MCU or smaller.

The following three main areas of concern were identified by the group:

- The connector must have adequate load-bearing strength to support the LRU.
- EMI/EMP requirements are not adequately addressed in the ARINC-600 design. Development effort and validation testing are needed.
- Connector electrical continuity under dynamic loads needs to be tested. Other connector development work and testing are also needed.
- Connector inserts should be interchangeable between different manufacturers.

4.3.4 Findings of Planning Working Group

Bobby Jones, ASD/ENO, introduced the briefers for the Planning Working Group results: David Featherstone for the ARINC-600 addendum, John Kidwell for tri-service coordination, and Ken Ricker for implementation.

4.3.4.1 Addendum to ARINC Specification 600

David Featherstone, ARINC/AEEC, presented the results of the revised draft appendix to ARINC-600 for military applications. The major groupings of applications are:

- Civil equipment designs covered by the basic ARINC-600
- MIL-STD-XXX designs for military fighters
- Mid-ground applications covered by the new Appendix to ARINC-600

The introductory paragraph was revised for clarity. The vibration requirement was imposed as a random vibration test at 0.04 g^2/Hz, 20 to 1,000 Hz, to check general ruggedness of civil equipment in military applications.

For cooling, openings in the equipment case to aid free convection are permitted. There may be a reliability degradation for units operated in unpressurized bays, and this needs case-by-case evaluation. The power-dissipation limits given are to be treated as "never exceed" values. Collecting exhaust cooling air is optional.

Parts quality (e.g., acceptability of plastic-encapsulated components) should be addressed by other specifications.

Salt spray requirements are not imposed.

There was a questions from the floor as to what major change is imposed by this addition to the existing ARINC-600. The answer was that the purpose is to provide guidance for the military application of civil equipment.

4.3.4.2 Tri-Service Applicability of MIL-STD-XXX

John Kidwell, NAC, presented tri-service views on the MIL-STD-XXX activity. There is a good chance for use of the standard. However, it is likely that many changes will be introduced during the military review process, such as additional requirements for Army helicopter operation. In addition, the acceptance of rear-mounted blind-mating connectors by the Navy will be difficult to achieve. There is common motivation and interest such as cost/reliability/maintainability and DoD directives.

4.3.4.3 Implementation Aspects of MIL-STD-XXX

Ken Ricker, ASD/AXP, addressed the implementation aspects of the standard. Administratively, the product must be submitted into the formal review process. A conservative estimate of this approval process is 12 to 18 months. A number of tests and studies must be completed in parallel with the approval cycle.

The advocacy of this standard will be a joint responsibility of industry and government, with many of the key people in attendance at this open forum. Other involved organizations are DMSSO and the Joint Services Review Committee.

The Air Force candidates for the standard are the C-X and ATF. Concepts could be tested in the Total Avionics Integration Demonstration (TAID) Program.

4.3.4.4 Open Discussion

Questions and answers were presented as follows:

- Is ARINC going to present the ARINC-600 addendum at Houston this year? Yes; if there are no objections to the addendum as written, we will put it on the agenda.*
- The road ahead for the connector does not seem clear. Unless we get the MIL-SPEC connector, we will not get the MIL-STD. We need to press this first. Are we going to leave the connector requirements in the standard or include them separately in a connector specification? At this time, we will leave them in the standard; it will take some time to get the connector specification going.
- There is no reason to close out the open forum activity. Why not get together in smaller groups such as the connector group? We will be going back to you in smaller groups. We will probably not have another large forum on MIL-STD-XXX.

4.3.4.5 Conclusion of Open Forum

Dick Ittelson reviewed the forum's progress against the initial objectives:

- MIL-STD-XXX. The draft, as it stands, is not ready for service coordination. The current draft will be revised by ARINC Research and resubmitted for review by government personnel.
- Military Addendum to ARINC-600. We have a workable draft; it will get to AEEC for the next general sessions.
- MIL-STD-YYY. We have made a start; more study and further review are indicated.
- High-Power Addendum to MIL-STD-XXX. Again, further study is needed.

*At the December 1981 General Session, the AEEC adapted by consensus Supplement 4 to ARINC Specification 600, defining the additional environmental requirements for military users of air transport avionics equipment.

CHAPTER FIVE

ISSUES AND SUGGESTED RESOLUTIONS AND PLANS FOR THE COMPLETION OF PME STANDARDS DOCUMENTATION

In this chapter the issues that remained unresolved at the end of the second open forum are reviewed, their criticality is evaluated, and a schedule of tasks needed to resolve them is drawn for each of the planned PME documents. These issues are listed in Table 5-1. Sections 5.1 through 5.4 address the individual issues that have been identified and suggest a recommended solution or a course of action planned to lead to an acceptable resolution of the issue. Section 5.5 summarizes the continuing actions needed and presents a planning schedule for their timely completion.

5.1 MIL-STD-XXX ISSUES REMAINING TO BE RESOLVED

5.1.1 Acceleration Design and Test Levels

5.1.1.1 Discussion of Issue

The maximum acceleration levels acceptable to the Air Force do not include the levels necessary for carrier landings (see Table 5-2). An increment due to angular accelerations also needs to be added.

Civil avionics are certified to a repeated shock test totaling 18 11-millisecond shocks at 6 g amplitude (operation), followed by 18 11-millisecond shocks at 15 g amplitude (crash safety).

For military aircraft, MIL-E-5400 requires the same test at the greater amplitude of 15 g (operation), and 12 crash safety shocks at 30 g.

5.1.1.2 Recommended Action

Tri-service needs should be reconciled, and an agreed requirement for MIL-STD-XXX and MIL-STD-YYY should be coordinated.

5.1.2 Strength of Attachment Points

5.1.2.1 Discussion of Issue

Analysis and testing have shown that the ARINC-600 connector shells must be attached to adequately stiffened structural members of the LRU (for

Table 5-1. ISSUES REMAINING TO BE RESOLVED
MIL-STD-XXX
• Acceleration design and test levels • Strength of attachment points: LRU and tray • Location of air inlets relative to connector on backplate • Air closure when LRU is removed • LRU operation following ECS degradation or failure • Alternative front connector for retrofits option • Low-profile mounting provisions: required or optional • Recommended bonding method • Thermal design evaluation procedure • Mechanical design evaluation procedure
Connector MIL-SPEC
• Environmental design and test requirements • Electrical performance in vibration or shock environment • Bonding-to-ground provisions in connector • Environmental seal, EMI/EMP protection, and mechanical strength • Additional connector sizes
High-Power-Dissipation Addendum to MIL-STD-XXX
• How much to extend beyond basic MIL-STD-XXX • Which parameters should be extended? •• Power dissipation •• Additional cooling air •• Higher pressure drop •• Liquid cooling •• Heavier LRU • Additional dimensional options •• Length •• Height •• Width
MIL-STD-YYY
• Definition of scope of application • Form factors for multifunction display units • Form factors by STANAG, MS sheets, or ARINC-408? • Touch temperatures • Ambient temperatures in cockpit • Character of cooling-air provisions in cockpit

Document	Operation					Structural Restraint				
	Fore	Aft	Up	Down	Lateral	Fore	Aft	Up	Down	Lateral
ARINC-600	9.00	9.00	4.50	2.00	9.00	--	--	--	--	--
MIL-STD-XXX	6.10	6.10	10.40	4.10	6.10	9.15	9.15	15.60	6.15	9.15
MIL-STD-810C										
Aircraft	2.00	6.00	9.00	3.00	4.00	3.00	9.00	13.50	4.50	6.00
Helicopter	2.00	2.00	7.00	3.00	4.00	3.00	3.00	10.50	4.50	6.00
Carrier-Based Aircraft	4.00	12.00	18.00	6.00	8.00	6.00	18.00	27.00	9.00	12.00
Current Navy Requirement	6.00	6.00	21.00	9.00	12.00	6.00	12.00	27.00	9.00	12.00

Table 5-2. ACCELERATION DESIGN AND TEST LEVELS (g UNITS)

the receptacle) and the backplate or mounting tray (for the plug). However, related issues concern front mounting, as well as EMI and EMP shielding of the connector plug (see Section 5.2.3). A change to the configuration of at least the connector plug shell is needed to address these three issues. Following that action, a comprehensive validation test program will be needed to qualify the connector shells to military structural, vibration, and EMI shielding requirements.

5.1.2.2 Recommended Action

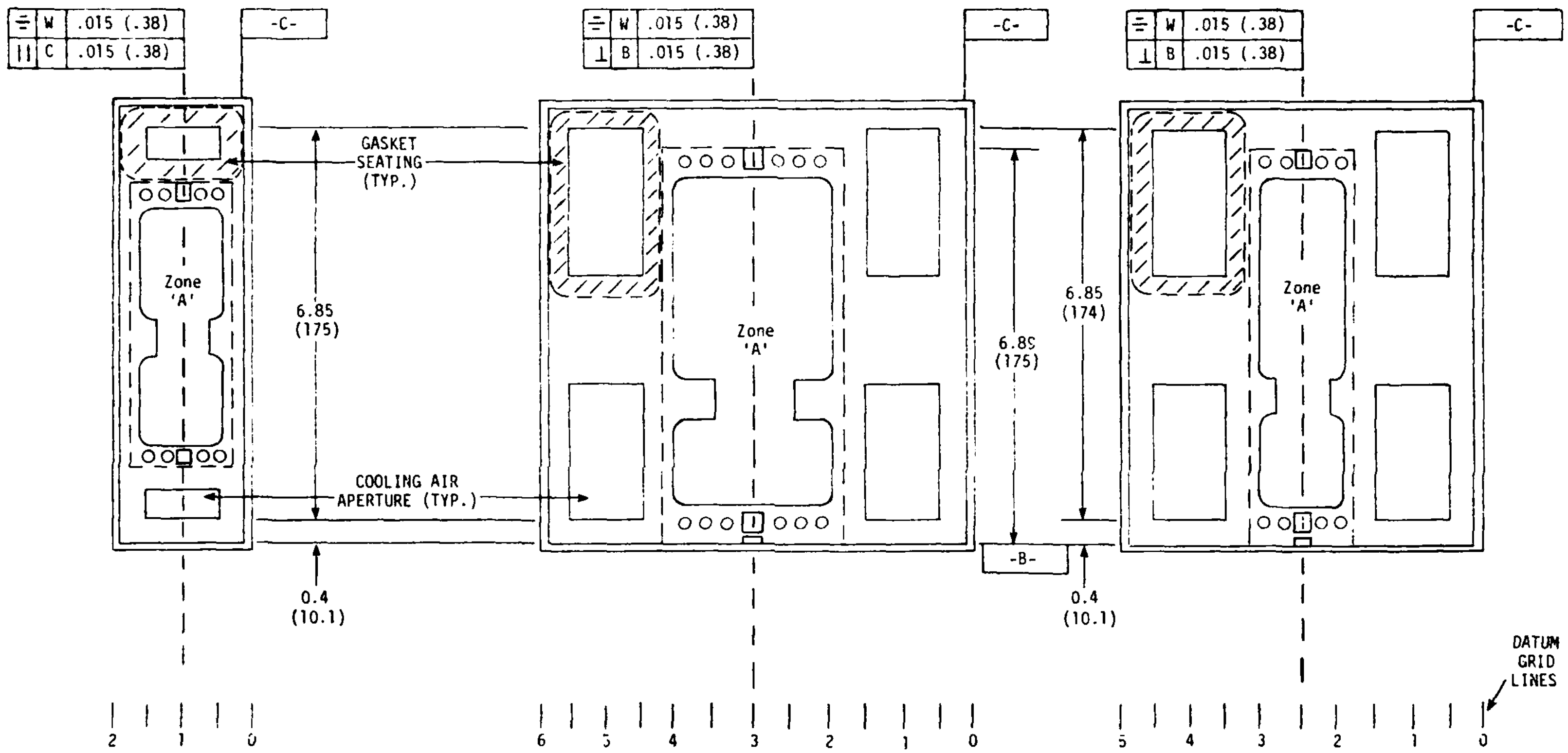
The following actions should be taken:

- Draw up connector specification requirements (see Section 5.2)
- Solicit design proposals
- Procure qualification test samples

5.1.3 Location of Cooling-Air Inlets

5.1.3.1 Discussion of Issue

Two open forums have supported the concept of the rear-mounted connector and collocated cooling-air apertures without agreeing on a specific layout. There are currently two favored configurations, one adapted to small units with top and bottom heat exchangers (and needing a reduced-height connector), and the other compatible with the standard connector configuration but having its cooling-air apertures in one or more of the four corners of the backplate (see Figure 5-1). Airframe installers favor the top/bottom configuration, because they envisage parallel air duct and cable raceways running horizontally across an array of backplates (Figure 5-2) as compared with individual cooling-air "risers" for each LRU, intermixed with the cable harnesses (Figure 5-3). Clearly, mixing the two configurations of LRUs would create a chaotic air-distribution network. On the other hand,



NOTE: DIMENSIONS ARE INCHES (MILLIMETERS).

Figure 5-1. LOCATION OF CONNECTOR AND COOLING AIR APERTURES

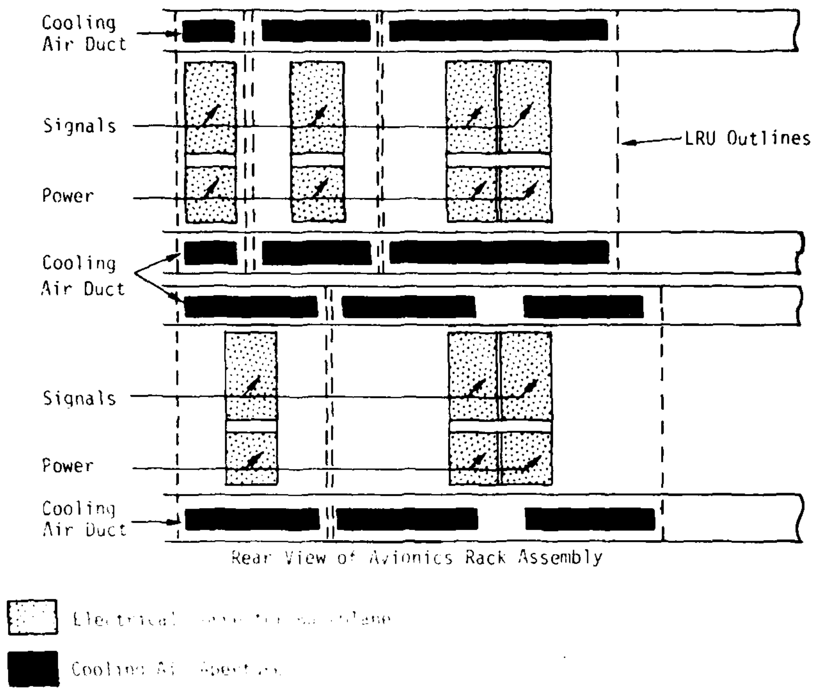


Figure 5-2. PARALLEL COOLING AIR DUCTS AND CABLE RACEWAYS

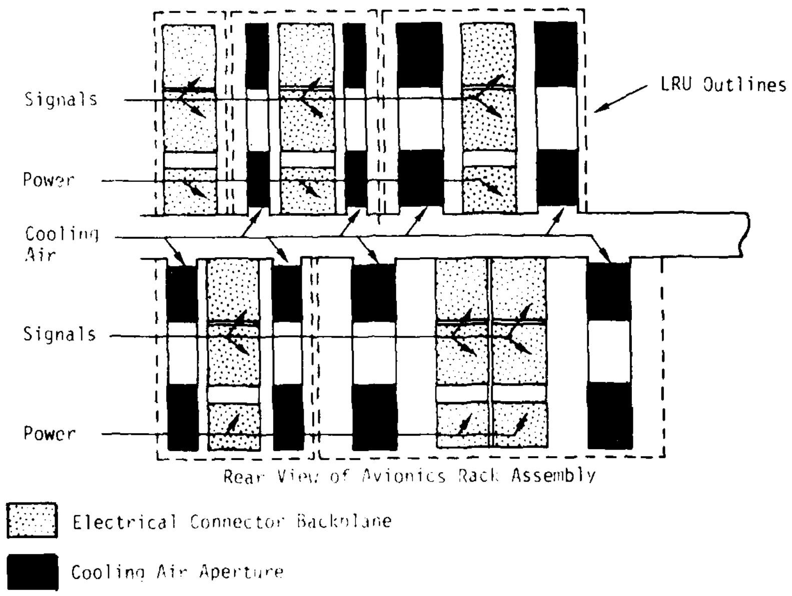


Figure 5-3. CROSSED COOLING AIR RISERS AND CABLE BUNDLES

having two incompatible configurations is inconsistent with the objective of flexibility of location (and relocation) of LRUs in an aircraft and among aircraft of different types.

5.1.3.2 Recommended Action

Development of a connector configuration adaptable to the top/bottom cooling-air inlet configuration for LRUs of all sizes should be initiated.

5.1.4 Air Closure When an LRU Is Removed

5.1.4.1 Discussion of Issue

This need is associated with the increased pressure required to maintain the flow of cooling air against the friction losses in heat-exchanger LRUs. A device on the airframe side of the interface should close sufficiently to prevent the diversion of cooling air away from the remaining LRUs when one LRU is temporarily removed.

5.1.4.2 Recommended Action

MIL-STD-XXX, paragraph 5.2.3.2, has been changed to include this guidance.

5.1.5 LRU Operation Following ECS Degradation or Failure

5.1.5.1 Discussion of Issue

The continuing operation of most avionic systems is necessary to mission success. There must therefore be a viable back-up configuration in case of ECS failure. The avionics LRUs must continue to operate through transition into the back-up ECS configuration. Establishing the back-up configuration may take time and involve restricting the aircraft's subsequent flight envelope (e.g., to establish an effective ram air cooling configuration). If this is unacceptable to the mission, then full ECS back-up to mission-critical avionics would have to be provided.

The standard LRU has been required to perform normally through a 10-minute interruption of cooling-air supply and through 30 minutes of emergency ram air cooling (MIL-STD-XXX, paragraph 5.1.4). Where appropriate to the mission and the avionics function concerned, automatic "power down" should be allowed to protect the LRUs from burn-up in the event that the supply of cooling air fails.

5.1.5.2 Recommended Action

Commentary should be added to MIL-STD-XXX to include this requirement.

5.1.6 Alternative Front Connectors for Retrofits Option

5.1.6.1 Discussion of Issue

Where it is necessary to interface with existing pendant cable connectors (with receptacles on the front face of the LRU), the rear holddown is no longer provided by the connector shell. Draft MIL-STD-XXX now calls for the lip configuration of MIL-C-172 (MS 91402 and MS 91404), adapted to include a backplate in the tray for applications where the standard cooling-air interface is required.

5.1.6.2 Recommended Action

Coordinate suggested resolution.

5.1.7 Low-Profile Mounting Provisions: Required or Optional

5.1.7.1 Discussion of Issue

These provisions arose (1) from a commercial manufacturer's comment about repeated requests for design approval to mount various ARINC-404 LRUs in a horizontal rather than vertical position, (2) from fighter aircraft installation department comments that the proposed 7-5/8-inch height would be too tall for some locations, and (3) from previously encountered service requirements for freedom to mount LRUs in any attitude.

The draft standard now calls for LRU sizes 2, 3, 4, and 5 to have provisions for the optional attachment of NAS 622 Type T holddown hooks on the left-hand side, so that any such unit can be readily reconfigured in the field for sideways mounting. If these provisions are omitted, separate spares holdings will be needed to support the "low profile" installations as compared with the standard installations.

5.1.7.2 Recommended Action

Present intent and wording should be implemented.

5.1.8 Recommended Bonding Method

5.1.8.1 Discussion of Issue

Radio frequency (RF) and power ground return independent of the pin and wiring connector circuits is specified. Trade-off and design studies could select and detail one or more technically acceptable methods of realizing those requirements. The connector shell and the front holddown/extractor screws are points of potentially firm electrical contact that might serve this purpose.

5.1.8.2 Recommended Action

Airframe prime contractors, avionics LRU suppliers, connector suppliers, installation contractors, and service agencies should be asked to describe and submit their preferred grounding methods.

5.1.9 Thermal Design Evaluation Procedure

5.1.9.1 Discussion of Issue

The MIL-STD-XXX Thermal Design Evaluation Procedure was completely restructured by the second open forum. Further review, completion, and coordination are needed.

5.1.9.2 Recommended Action

The new strawman Appendix I to MIL-STD-XXX should be reviewed and refined.

5.1.10 Mechanical Design Evaluation Procedure

5.1.10.1 Discussion of Issue

A MIL-STD-XXX Strawman Mechanical Design Evaluation Procedure has been prepared by ASD/EN. The draft requires review and coordination with other open forum attendees.

5.1.10.2 Recommended Action

Strawman Appendix II to MIL-STD-XXX should be circulated for review and comment.

5.2 MILITARY STANDARD CONNECTOR ISSUES REMAINING TO BE RESOLVED

The availability of a validated production design, qualified connector is vital to the implementation of the LRU standard. A first step is to transform into MIL-SPEC terms the present commercial (Boeing) specification under which ITT Cannon, Souriau, and AMP are producing ARINC-600 connectors for the commercial airline market. This specification should also address the additional requirements expressed in Draft MIL-STD-XXX for military applications, including revised shell sizes 2A and 3A to accommodate standard inserts in alternate shell configurations.

The connector issues to be clarified for the preparation of a connector MIL-SPEC project are discussed in the following subsections, with recommended actions.

5.2.1 Environmental Design and Test Requirements

5.2.1.1 Discussion of Issue

MIL-STD-1344 is referenced for most of the test requirements in the Boeing (commercial) connector specification. A general military requirements package for this series of connectors is needed. The specific configuration and performance requirements attributable to MIL-STD-XXX needs, based on the Boeing specification and the open forum findings, can then be added.

5.2.1.2 Recommended Action

A draft MIL-SPEC for the connector should be prepared on the basis of MIL-C-83723 (for format and content), Boeing SCD10-61953 (for basic dimensions and tolerances), and draft MIL-STD-XXX open forum findings, including new size 2A and 3A configurations.

5.2.2 Electrical Performance

5.2.2.1 Discussion of Issue

Using MIL-C-83723C as a model will ensure including all of the traditional (lessons learned) connector design requirements. Additional attention is now directed toward anomalous performance under vibration and shock environments in the nanosecond regime (50 to 1,000 nanoseconds), where interruptions will degrade serial digital data transmission.

5.2.2.2 Recommended Action

A vibration and shock testing program should be sponsored.

5.2.3 Bonding and Grounding Provisions (see also Section 5.1)

5.2.3.1 Discussion of Issue

If a reliable power fault and RF path to the airframe ground through the mated, load-bearing connector shells could be designed, defined, and validated, then it would not be necessary to pursue other grounding provisions that depend on metal-to-metal contact with the tray, guide rails, or holddown/extractor screws, or on links or jumpers added after installation.

5.2.3.2 Recommended Action

Bonding and grounding requirements should be included for the design change proposals to be solicited as recommended in Section 5.2.4.2.

5.2.4 Environmental Seal, EMI/EMP Protection, and Mechanical Strength

5.2.4.1 Discussion of Issue

Addressing the present ARINC-600 connector design, primarily that of the plug, the open forum reached the following conclusions:

- It would be impractical to make an environmental seal between the mounting structure (backplate) and the connector shell.
- It would be impossible to properly terminate (i.e., seal electrically) an EMI cable shield or duct on the back side of the connector plug.
- It was not clear that the connector shells would support the back end of the LRU to the maximum weight limit and maximum acceleration loads being specified.

- The means of attachment between the connector shells and the rack and LRU appeared to be inadequate.

Our preliminary load testing confirmed this last finding. Correction of all of these potential problems requires rework of the shell design, but this need not have an impact on the insert design or intermateability with the present configuration of (commercial avionics) connector.

5.2.4.2 Recommended Action

Proposed changes should be solicited from connector suppliers to provide backshells with EMI shielding and environmental sealing, together with revised mounting flanges and fastener provisions designed to reduce the levels of stress in the diecast shells. Proposals should be coordinated into an agreed military configuration. (See also Sections 5.2.3 and 5.2.5.)

5.2.5 Additional Connector Sizes for Military Applications

5.2.5.1 Discussion of Issue

The ARINC-600 connector series was designed for the ARINC-600 "bookshelf LRU" concept; these connectors occupy essentially the full height of the LRU and backplate. For military installations, where cooling-air inlets are also to be located in the backplate, a shortened version of the connector has been proposed. This version uses the same inserts interchangeably with the present size 2 and size 3 connectors but omits the upper 150-signal pin insert in each case. These connectors have been referred to as size 2A and size 3A.

5.2.5.2 Recommended Action

Evaluation and qualification test prototypes of size 2A and size 3A connector shells should be procured.

5.3 HIGH-POWER DISSIPATION ADDENDUM

5.3.1 Discussion of Issue

The intent of the High-Power-Density/High-Dissipation Addendum to MIL-STD-XXX requires clarification. MIL-STD-XXX originally intended to restrain reckless disregard of real thermal environment limitations and forseeable reliability compromises in the design of avionics LRUs, in a manner similar to that adopted by the AEEC for ARINC Specification 600. MIL-STD-XXX was therefore scoped to exclude avionics functions that derive a clearly identifiable military advantage from using extremes of power density (e.g., ultra-high-speed signal processors), extremes of total power (e.g., jamming transmitter amplifiers), and large or heavy LRU assemblies (e.g., radar modulator/transmitter units). Such types of LRU are often installed in some specific aircraft location away from the general-purpose avionics bay, so that they will have the shortest possible

RF cable (or waveguide) run to their associated antennas. These LRUs would provide little benefit by complying with the PME racking standard (MIL-STD-XXX), but the definition of a limited number of configuration options could reduce the future proliferation of aircraft-unique envelope form factors and physical interface details for functionally equivalent LRUs.

5.3.2 Recommended Action

The following actions are recommended:

- Clarify Air Force requirement/objectives for MIL-STD-XXX High-Power-Dissipation Addendum
- Review strawman addendum, with user, manufacturer, and airframe designer participation
- Compile revised draft for coordination

5.4 MIL-STD-YYY ISSUES REMAINING TO BE RESOLVED

5.4.1 Definition of Scope of Application of MIL-STD-YYY

Working group discussion of "Paragraph 1 - SCOPE" and planned follow-up activity indicated a strong interest in pursuing the proposed document as an "Interface Standard" (not a design standard). It would be applicable to control and display units (CDUs), multifunction displays (MFDs), electronic flight instruments (EFIs), and standard instruments. Implementation of such a standard would be subject to many influences, but well coordinated guidelines for normal design (in the form of the proposed standard) will be a prerequisite for any progress in commonality and interchangeability of cockpit-mounted equipment. One issue is agreement on the definitions and nomenclature of the classes of LRU mentioned above.

5.4.2 Form Factors for Multifunction Displays

It has been noted that display dimensions are often set by available cockpit space. One of the purposes of MIL-STD-YYY is to be the means of giving guidance to avionics manufacturers concerning the dimensional constraints on MFD design and giving guidance to airframe designers concerning the provision of cockpit space for MFDs (AFSC DH 2-2, Section 2A already determines the human-factors relationships for such elements as display size, eye distance, and control knob reach).

ARINC Specification 725, Electronic Flight Instruments, defines specific form factors for electronic altitude directors and horizontal situation indicators (but not uniquely); however, CRT attitude and compass displays have also appeared in the standard (ARINC-408) instrument form factor. ARINC-601 addressed a more general range of sizes for MFDs, but, as noted, further work is needed. The MS 25212 form factor has also been adopted for both commercial and military CRT displays.

5.4.3 Form Factors for Conventional Instruments

5.4.3.1 Flangeless Round Instrument Cases

The flangeless round instrument cases in four sizes are common to STANAG 3319, MIL (MS) Sheets, and commercial (ARINC-408) specifications. These are:

STANAG Size	MS 33639 Size	ARINC Size	Nominal Bezel Diameter
A1	1 inch	1	1-1/16 inch
A3	1-1/2 inch	1.5	1-1/2 inch
A4	2 inch	2	2 inch
A5	3-1/4 inch	3	3-1/8 inch

The STANAG adds a size A2, nominally 1-1/8 case size.

The commercial specification limits the case length behind the bezel to 9.00 inches (228.60 mm), excluding the connector.

The dimensional tolerance variations and "round off" differences are minimal.

5.4.3.2 Square-Flanged Round Instruments

The square-flanged round instruments appear in the STANAG (as Type B1, 2-1/4-inch case diameter; and Type B2, 3-1/8-inch case diameter) and MS 33638 identically except for tolerances on the flange and spigot thickness. MS 33638 adds a 1-1/2-inch case diameter instrument. This small instrument has a length between 1-3/8 and 1-7/8 inches; the lengths of the other sizes are "as specified." The commercial airline standard does not include these styles.

5.4.3.3 Square-Flanged Octagonal Instruments

MS 33556 and the STANAG size C2 are identical 3-1/4-inch square-flanged octagonal instruments. The other STANAG options are C1 (2-1/2-inch) and C3 (4-inch). The corresponding commercial configuration is flangeless and will fit the military panel cut-out when clamp-mounted, but the adapter plates for flange mounting are oversize. MS 33545 defines a 5 × 5-1/4-inch instrument bezel on a 4-3/4 × 4-1/2-inch mounting-screw hole pattern. Other, functionally specified instruments defined by individual MS sheets employ variations of the MS/STANAG styles.

5.4.3.4 Flangeless Octagonal Instruments

This is the commercial airlines standard; it covers square and rectangular instruments from 1 × 2 inches through 6 × 6 inches nominal (see ARINC Specification 408). This standard is followed by the majority of international commercial aviation suppliers.

5.4.3.5 Recommendation

A consistent set of MS sheets should be prepared, in accordance with selected STANAG 3319 instrument sizes, for attachment to (or reference in) MIL-STD-YYY. In addition, ARINC-408 should be referred to for military use of commercial instruments in applicable transport aircraft and trainer aircraft.

5.4.4 Touch Temperatures, Cockpit Ambient, and the Character of Cooling-Air Provisions in the Cockpit

The existing strawman MIL-STD-YYY (following ARINC-601) specifies face temperature and control-knob temperature in °C above cockpit ambient. Normal cockpit ambient is 40°C, and normal cooling-air supply is at 30°C. MIL-E-87145 (Appendixes A and C) references human tolerance to excess heat in terms of "Pilot Envelope Temperatures: Compartment Average Temperatures; Skin Temperature and Threshold of Pain." MIL-E-87145 suggests the following upper temperature limits:

- Pilot Envelope Temperature: 27°C maximum (80°F, half-hour)
- Compartment Exhaust Temperature: 30°C maximum (86°F per equation, paragraph 3.2.2)
- Pilot Cooling-Air Supply: 15.5°C (60°F) assumed
- Touch Temperature:
  - Metal: 45°C (113°F), Table 1-1
  - Insulated or Gloves: 66°C (150°F), Table 1-2

As noted at the open forum, the avionics bay thermal design parameters (71°C ambient, 71°C LRU maximum steady-state surface temperature, and 71°C LRU exhaust to ambient) are not consistent with general cockpit design requirements. Proposals to copy the MIL-STD-XXX thermal specifications into MIL-STD-YYY should be reevaluated.

5.4.5 Recommendations for MIL-STD-YYY Development

The ASD/AX proposal to convene a continuing (periodic) ASD working group on cockpit display hardware should be followed up.

5.5 RECOMMENDATIONS AND SCHEDULE

Figures 5-4 and 5-5 are planning schedules for the tasks identified in this chapter as necessary for continued progress toward timely approval and application of the three key "MIL" documents:

- Avionics Bay Interface Standard (MIL-STD-XXX)
- Rack and Panel Connector Specification (MIL-C-XXX)
- Control and Display Interface Standard (MIL-STD-YYY)

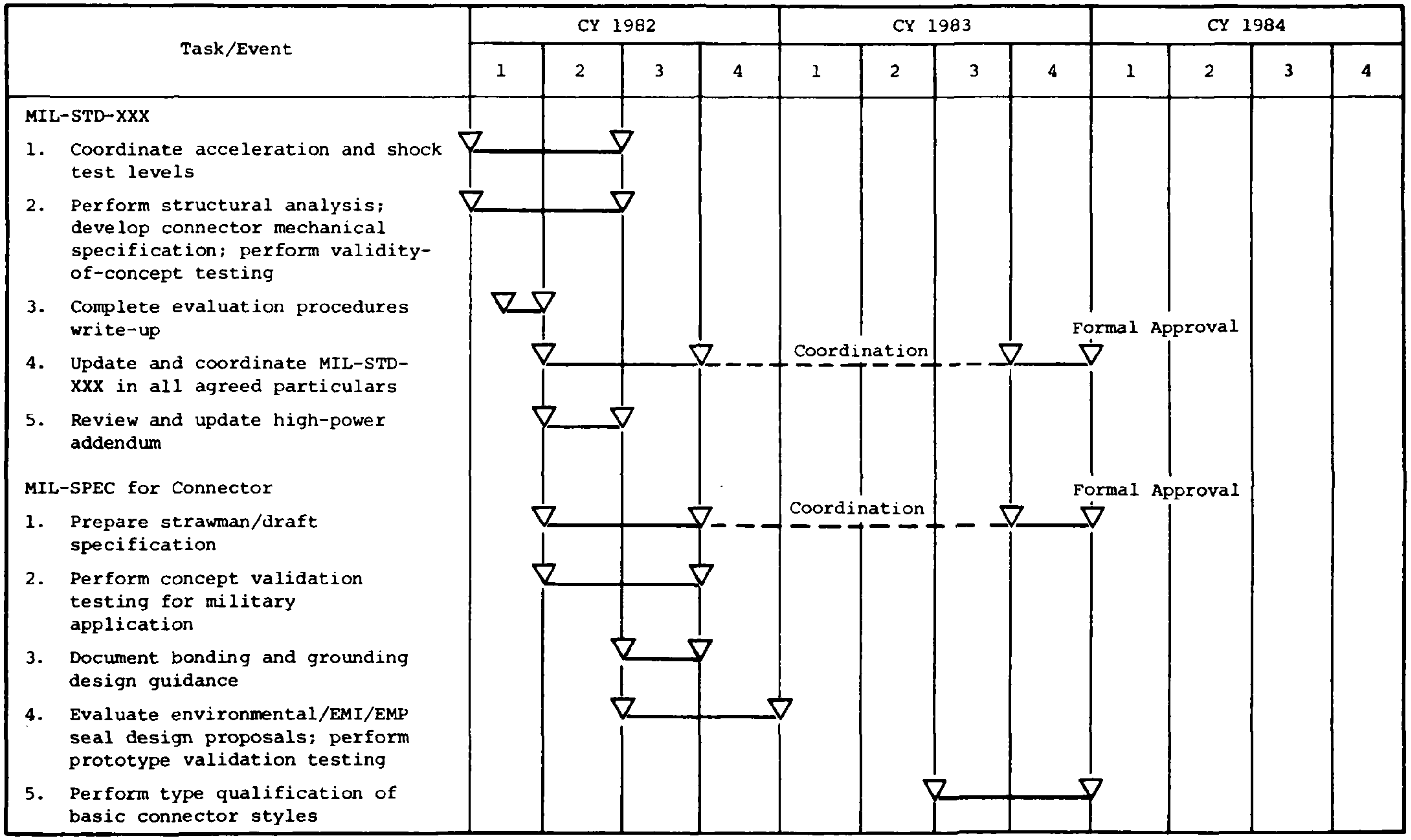


Figure 5-4. TASK SCHEDULE FOR MIL-STD-XXX

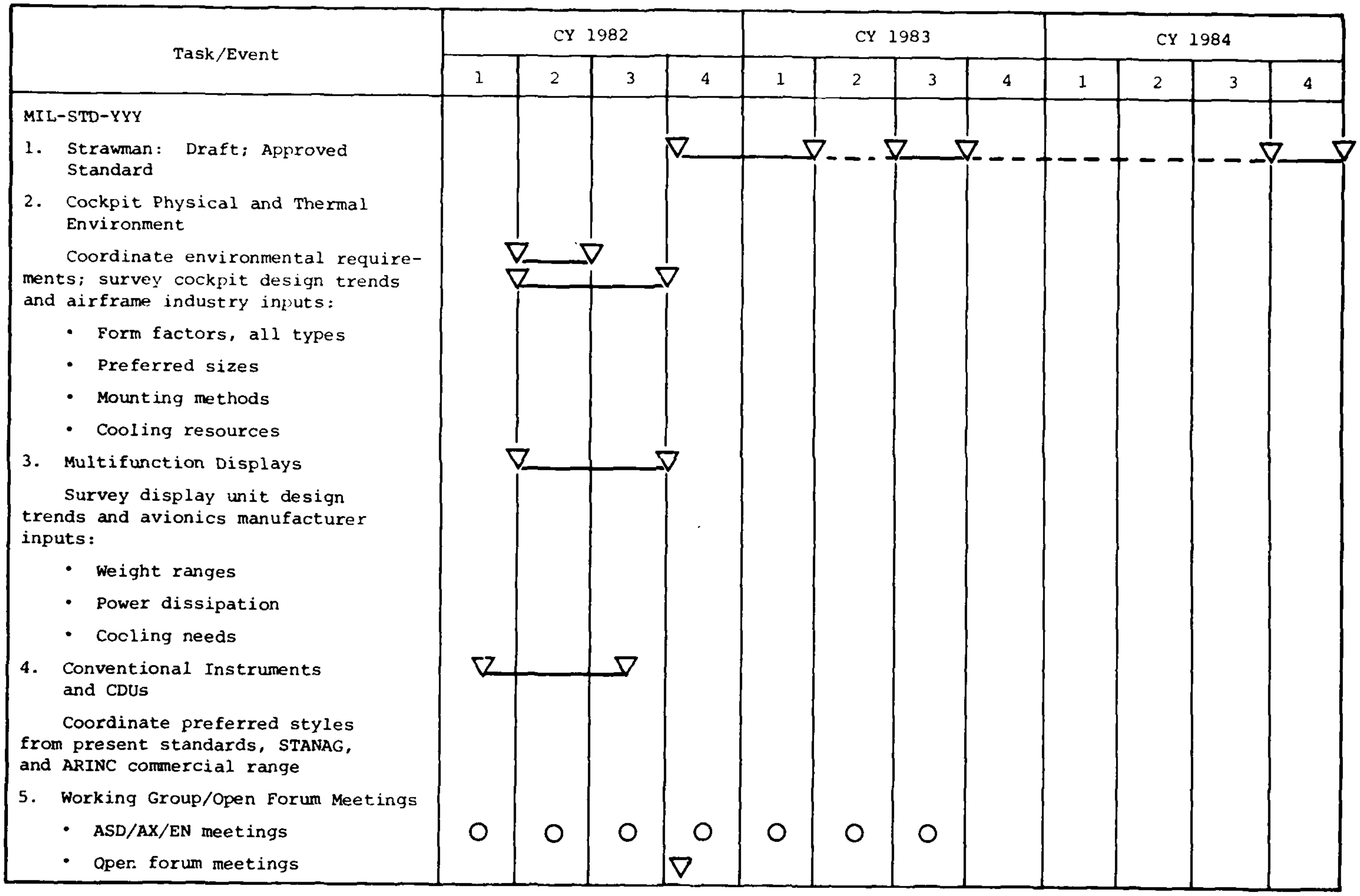


Figure 5-5. TASK SCHEDULE FOR MIL-STD-YYY

5.5.1 Avionics Bay Interface Standard (MIL-STD-XXX)

The key milestone for both MIL-STD-XXX and MIL-C-XXX is to agree and coordinate on a common cooling-air delivery concept with which any MIL-STD-XXX LRU could be made compatible. Such a decision would allow the agreed connector rework activities to move ahead with confidence, to enable validated connector hardware to be produced in time for the MIL-STD-XXX black box development or repackaging programs that should be under way in 1984. Early efforts are needed to demonstrate the validity of the MIL-STD-XXX structural and cooling concepts and connector electrical integrity in support of this key decision. The Boeing Aerospace Company report (Contract N00163-81-C-0011, in draft) provides preliminary results in this area.

Together with the above-mentioned key decision, the other outstanding issues remaining for MIL-STD-XXX should be addressed concurrently, so that a final draft of the standard can be entered into the formal coordination and approval process as early in 1982 as possible. Working group meetings should be arranged, including Air Force and industry representation, to address the requirements of specialized high-power-density and high-power-dissipation equipment, with the objective of submitting a coordinated "High-Power-Dissipation LRU" addendum early enough to be included in the final approved version of MIL-STD-XXX.

5.5.2 Rack and Panel Connector Specification (MIL-C-XXX)

Once the LRU and rack backplate configuration is agreed upon, currently available design and intermateability data (included in the MIL-STD-XXX and original ARINC-600/NIC documentation) and military design and performance requirements applicable to currently MIL-qualified connectors should be combined to produce a draft connector MIL-SPEC for MIL-STD-XXX applications. Specific design and requirements data should evolve from the structural/EMI/EMP analyses that are scheduled under Section 5.5.1. Specific electrical performance and durability requirements are stated in MIL-C-83723C. Configuration considerations suggest (and we recommend) that the MIL-SPEC should describe a connector system comprising several shell arrangements, a standardized shell-to-insert interface, and an expandable set of mechanically interchangeable inserts closely based on the existing ARINC-600 commercial connector system. The referenced Boeing Aerospace Company report includes important comments and suggestions on mechanical strength, EMI/EMP shielding, and grounding.

5.5.3 Control and Display Interface Standard (MIL-STD-YYY)

The Control and Display Working Group of the second open forum concluded that more in-house study by ASD/EN was needed before a fresh draft of MIL-STD-YYY could be prepared (see Section 4.2.9.1), and that industry participation in the selection of preferred multifunction display sizes, weight limits, power limits, and cooling methods would be most appropriate. The recommended planning schedule therefore includes regular ASD steering committee meetings through 1982 and 1983. Separate task elements are scheduled through mid-1982 to study and resolve environmental specification issues, form factors, and preferred sizes for multifunction displays and conventional instruments, so that an updated strawman standard can be prepared for government/industry review late in 1982. MIL-STD-YYY could then be ready to enter the formal military coordination process during 1983.

CHAPTER SIX

THE STANDARDS APPROVAL PROCESS AND EARLY IMPLEMENTATION STEPS

While the participants in the second open forum drafted elements of a revision to MIL-STD-XXX that satisfied a consensus of those present, several issues still remain to be resolved and many people and organizations must be educated to the need for the proposed standard before its approval will be forthcoming. This chapter provides a brief examination of the overall process for approving the draft standard, the initial steps recommended by ARINC Research as necessary for successfully meeting that process, and the events in addition to approval needed to achieve the installation of PME standard equipments in military aircraft.

6.1 THE STANDARD AND SPECIFICATION APPROVAL PROCESS

A draft standard or specification must go through many steps in military channels before it becomes an approved document. Before it enters administrative channels for formatting, editing, graphics work, typing, and formal coordination cycles, it must be technically validated by appropriate engineering support organizations. This process includes review and approval of any necessary design, prototyping, testing, and qualification of the technical elements to ensure their achievability. At ASD, where MIL-STD-XXX and -YYY would receive initial technical staffing and approval, the Directorate of Engineering (ASD/EN) performs this function. Factors such as reliability, maintainability, testability, human factors, EMI/EMP, safety, and environmental provisions are reviewed for adequacy and accuracy. Several levels of review and approval are involved. A generalized diagram of this process is shown in Figure 6-1. The time required to complete the process varies as a function of technical achievability of the contents of the standard, its acceptability by the communities who must approve it, and the urgency of its need. A recent Air Force estimate places the time for this process to be somewhere between 12 and 18 months.

6.1.1 <u>Technical Achievability</u>

The issues associated with MIL-STD-XXX and -YYY encompass a wide range of technical uncertainty. An issue such as the method to be used for bonding, requiring principally assessment of alternatives and a decision, could be considered to represent low technical risk. Another example of a low-risk technical issue is the use of an optional front location for a

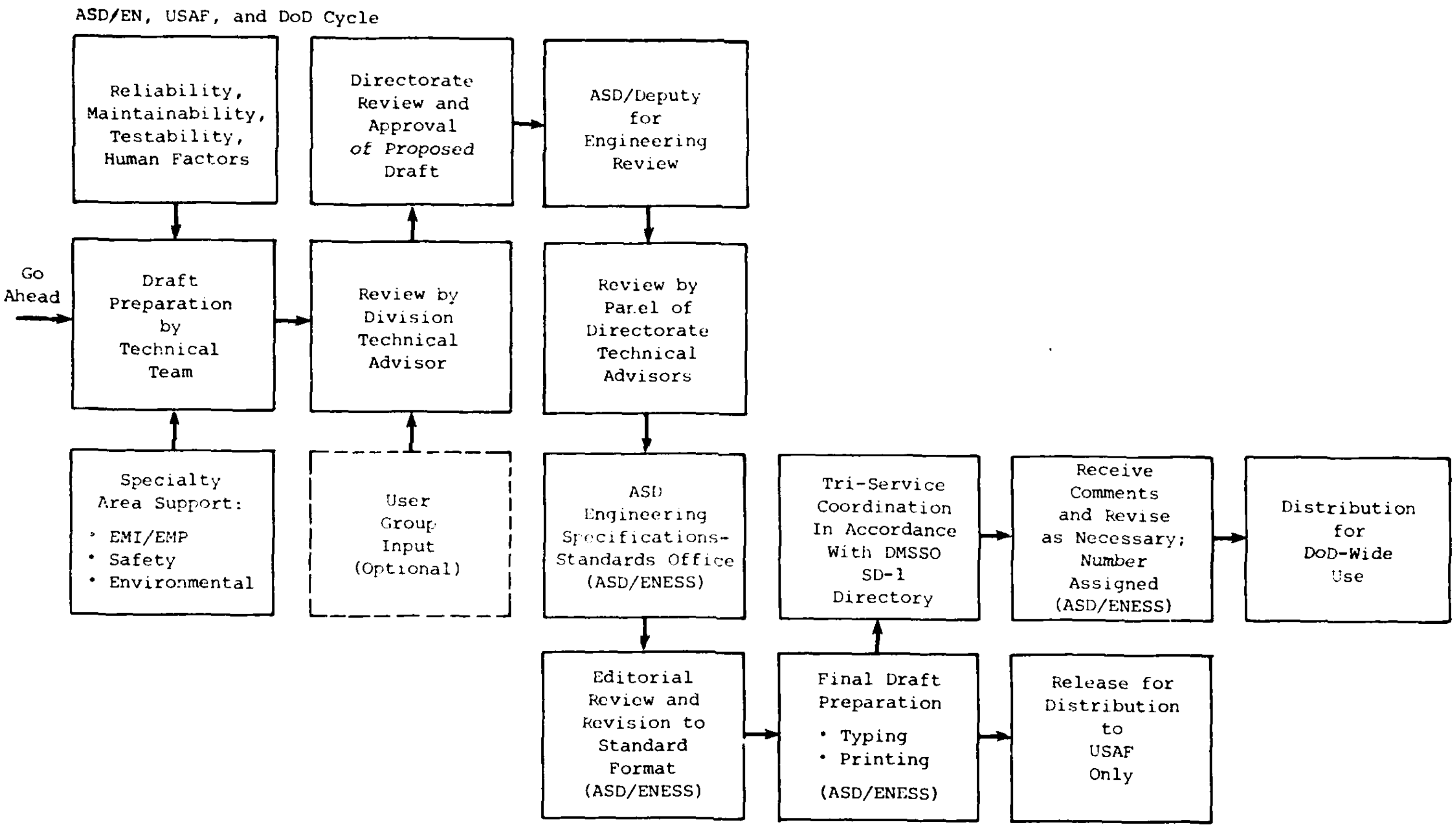


Figure 6-1. ASD/USAF STANDARDS AND SPECIFICATION APPROVAL CHANNELS

connector that would be used in some retrofit applications. While an option such as this in a standard is not necessarily desirable in and of itself because of the proliferation it can create, it nevertheless does not constitute significant technical risk. On the other hand, the cooling-air inlet ports are currently being proposed in two configurations: (1) a box-wide channel at both top and bottom of the LRU rear face, coupled with a shortened version of the ARINC-600 connector; and (2) a version with four openings located at corners of the LRU's rear face, with a full-sixe ARINC-600 connector. In this dual configuration, two technical problems of moderate to high risk occur: (1) the requirement to design and qualify a new connector, and (2) design constraints on aircraft cooling ducts and wiring that can deny interchangeability of locations between the two LRU configurations.

The more complex and higher-risk issues require some work toward resolution before the draft standard would even be eligible to be distributed into formal coordination cycles. However, the approval process could be undertaken with low-risk issues incorporated in the draft standard and with appropriate work plans underwritten to resolve the moderate and higher-risk issues. This approach suggests concurrency for preliminary staffing of the standards and resolution of its major issues. This idea is shown in Figure 6-2, which covers the general scope of schedules for issue resolution, standards approval, and early hardware implementation plans.

6.1.2 Standards Acceptability

A standard is only as useful as its acceptance by the communities that would use it. As the Chairman of the AEEC has noted from his past experience with development, producer, and user groups, "Standards are either too early or too late. There never is a right time." The implication is that unless given a judicious nudge, many of the key participants in the installation of avionics into aircraft would avoid using a standard at all.

In the case of MIL-STD-XXX, which was engendered in the Air Force Avionics Planning Conference process, many people from many communities participated in its conception and early development. Most of the people understand and agree with its potential value, and they advocate its implementation and use. However, many other people in the same communities, as well as some not yet involved, will probably participate in the standard's review, coordination, and approval or defeat, depending on their viewpoints, technical opinions, and assessments (good or bad) of its value.

To ensure success of the MIL-STD-XXX and -YYY concepts, we recommend that a program of education and advocacy be undertaken in conjunction with the approval-process schedule. The value of these standards must be completely understood so that advocacy follows and becomes contagious from managers and staffers in OSD to the installers and maintenance people on the flight line. This goal suggests a campaign to brief, discuss with, and answer questions of all of the potential players, and convince them of the

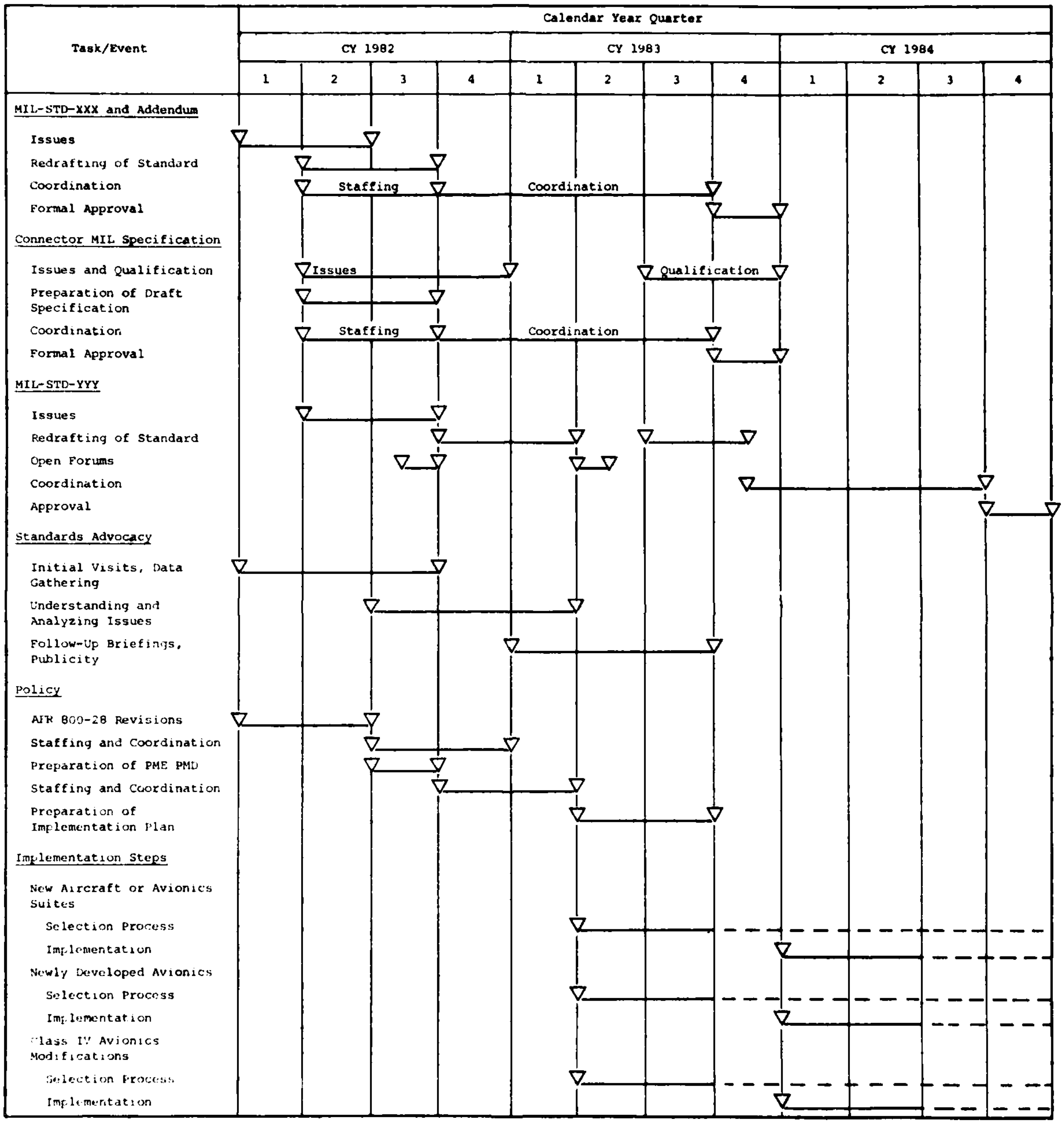


Figure 6-2. SCHEDULE FOR ISSUE RESOLUTION, STANDARDS APPROVAL, AND EARLY IMPLEMENTATION STEPS

values and benefits to be gained through a PME approach as initiated by MIL-STD-XXX and -YYY. A series of visits and briefings appears to be a good way to undertake these efforts to encourage acceptability through understanding. The visits should begin with the objective of providing basic information and learning user issues and concerns, followed by analysis and resolution of those concerns and positive feedback through subsequent briefings, papers, and other promotional material. These activities, shown in Figure 6-2, correspond to the activities undertaken to resolve technical issues and coordinate the draft standards.

One further step that should be considered for concurrent action, together with the approval process and advocacy, is the development of appropriate policy and early implementation decisions to put the new standards to use.

6.2 POLICY AND EARLY IMPLEMENTATION STEPS

Air Force Regulation 800-28, "Air Force Policy on Avionics Acquisition and Support," 11 September 1978, sets the Air Force tone and attitude on avionics standardization. It requires, among other things, the development of families of functional standards, avionics interoperability consisting of compatible technical interfaces, and early definition and specification of external interfaces within cost and performance constraints. The implementation of PME standards such as MIL-STD-XXX and -YYY, therefore, comes under the purview of current policy and carries out the Air Force philosophy to promote interchangeability and reduce unnecessary proliferation. At this point, however, it would be judicious to consider some amplification of that regulation to incorporate the specific tenets of PME standardization. A specific requirement to use MIL-STD-XXX and -YYY external interfaces (where not otherwise waived) would be a step in exercising the necessary discipline of form and fit standardization and a major step toward undertaking fully interchangeable F^3 standardization (where appropriate) in the future.

A necessary adjunct to indicate Air Force Headquarters support for the PME concept is issuance of a Program Management Directive (PMD) to guide the implementation phases of this standards program. It should address the specific activities to be considered for selection, justification, and incorporation of the standards on candidate equipments and aircraft in a methodical fashion for both the near term and the long term. It should also provide for a PME implementation plan. In this regard, we recommend a three-pronged approach for application of the new standards to (1) new aircraft or aircraft receiving largely new avionics suites, (2) newly developed avionics, and (3) certain classes of repackaged or retrofitted avionics. These approaches are discussed below.

6.2.1 New Aircraft or New Avionics Suites

Since one of the objectives of MIL-STD-XXX and -YYY is to engender major reliability initiatives, especially through the use of widespread environmental improvements, host aircraft must provide compatible rack, connector, and cooling system elements to maximize this PME benefit. These features are most easily accommodated during the aircraft design phase; therefore, new aircraft should be considered one major thrust of the PME standardization program. Older aircraft receiving entirely new avionics suites could also fall into the category of "new aircraft" from the perspective of avionics and for purposes of their installation. An older aircraft undergoing modernization to this extent represents both a major cost outlay and a continuing resource; thus the dollar costs of installing the standards should be considered as an investment opportunity. Some of the principal advantages and disadvantages that need to be considered in this approach are discussed below:

- Advantages
  - Current aircraft and avionics development programs are not affected by this approach; its acceptance should generally be forthcoming, since it does not impose itself on current programs or increase the use of their resources.
  - When the new aircraft or avionics suite design is implemented, the major benefits of PME standardization can be fully realized.
  - Commercial equipments that are responsive to mission requirements could be readily adapted to the airframe within the PME concept and could share the avionics suite design with MIL-STD-XXX and -YYY equipments.
- Disadvantages
  - Depending on timing, a new aircraft or new avionics suite may be in the design stage before avionic equipments built or repackaged to the new standards are available in useful variety or quantities. It could be argued that building a MIL-STD-XXX avionics bay into a new aircraft would not make sense if, for example, only two or three MIL-STD-XXX LRUs were available to be installed on the aircraft.
  - On older aircraft receiving new avionics, the cost penalties of reconfiguring shelves, connector/cabling, and air ducting, or installing new forced-air systems where these are not currently available, could be significant, and these costs may not be readily amortized. It might be necessary to perform careful trade-off analyses to make a valid implementation decision.

6.2.2 Newly Developed Avionics

When a new avionics system is under development, there is generally an opportunity for substantial design latitude before prototypes are built and form and fit decisions are made. If MIL-STD-XXX exists before packaging design is undertaken, the system's LRUs can, of course, be structured to meet the standard.

There are many newly developed and emerging systems that could be hastily offered as candidates for MIL-STD-XXX packaging, but care is needed in selecting systems in this category so as not to affect mission schedule requirements adversely or create costly changes that cannot be readily amortized. Appropriate cost trade-off analyses should be conducted where questions arise concerning the validity of redesigning or repackaging LRUs that already have tentative design parameters. Systems that are under serious consideration but are not yet configured, such as the Microwave Landing System avionics, make ideal candidates for application of the new standards for both avionics bay and cockpit units. The principal advantages and disadvantages appear to be as follows:

- Advantages
  - As in the case of new aircraft, all avionics that are not yet designed can fully incorporate the provisions of MIL-STD-XXX, given that they can be installed in similarly provisioned aircraft.
  - The form and fit for the avionics under development can be established for the new system and for subsequent generations.
  - The cost impacts of implementing the standard can be minimized if applied to new avionics that can incorporate it as a part of the development program.
- Disadvantages
  - Some candidates for the use of MIL-STD-XXX may already have made some design or packaging progress; thus some rework would be necessary to incorporate the standard's provisions. Delay of the development program or cost penalties could occur if implementation of the standards were mandated at this point.
  - Achieving implementation of MIL-STD-XXX or -YYY on new systems could take a long time to accrue a substantive variety and quantity of PME equipments.

6.2.3 Repackaged Avionics

The cost of applying MIL-STD-XXX and -YYY to existing avionics and aircraft could be quite large, since it would include both the LRU repackaging and the required aircraft reconfiguration. The smallest impact is achieved when an avionics or aircraft modification is already planned and the transition to MIL-STD-XXX or MIL-STD-YYY elements can be accomplished as a part of the modification program. The situation in which multiple aircraft types are undergoing Class IV modification appears to be optimum. In these circumstances, the modified system is essentially rebuilt and repackaged to a new specification defining both the functional and form factor interfaces common to all of the aircraft currently employing that system. This process was generally used to implement current Air Force "standard" systems such as the ARN-118 TACAN, the ARC-164 UHF Radio, the ARC-190 HF Radio, the Combined (High and Low) Altitude Radio Altimeter (CARA), and other avionics being procured through the Class IV modification process. NOTE: While these units are considered "standard" Air Force equipments, and have achieved many of the benefits of standardization, they were not built to a "family" of standard sizes and shapes and therefore exhibit elements of uniqueness. They are commonly referred to as "de facto" standards.

Since repackaging is usually an intrisic part of the Class IV modification process, the cost burden of applying MIL-STD-XXX or -YYY would be negligible for these avionics or controls and displays. The adverse consequence of this thrust is the likely impact on the aircraft modification costs if cooling air is not available, ducting modifications are extensive, or connector rewiring and placement create unacceptable costs or installation difficulties. The standard can be structured to overcome these consequences, but not without some penalty. For example, if cooling air cannot be provided, the avionics air inlets could be closed off, with a resulting loss in avionics reliability. As for the connector issue, the standard does currently provide for an optional front location that can be used if rear access is not viable. While these two situations would not permit full use of the benefits of MIL-STD-XXX, they would at least gear it to a transition status between current uniqueness and future full standardization. Decision on which of the upcoming Class IV modification programs would make viable MIL-STD-XXX and -YYY candidates must be made on a case-by-case basis to assess both cost and performance penalties for three circumstances: full, partial, or no modification of the airframe to accommodate the standardized units.

In general, this discussion leads to the following basic advantages and disadvantages of this approach:

- Advantages
  - Current avionics and airframes need not be excluded from PME standardization.
  - Even a partial standardization of either the LRU or the aircraft yields a transition state that can become the basis for full PME standardization for a subsequent-generation upgrade.
  - Many aircraft can be involved in the PME standardization program at the same time with a single Class IV modification.
  - The cost of any avionics LRU repackaging is normally included in a Class IV modification; this factor would be instrumental in reducing front-end standardization costs for the PME program.
- Disadvantages
  - MIL-STD-XXX avionics installed without benefit of cooling air lose the benefit of improved reliability intrinsic in PME equipments.
  - Avionics requiring front connectors could end up in two noninterchangeable configurations if some of them are later converted to use rear connectors. The Air Force would have to exercise close control to avoid counterproductive proliferation.

- • Installation of all avionics and controls/displays to MIL-STD-XXX and -YYY standards could incur high platform-modification costs to accommodate cooling and connector needs.

6.2.4 PME Standardization Levels

Figure 6-3 depicts the various levels of PME standardization achievable by implementing these three thrusts; it shows that modification programs can provide a transition state toward achievement of future full PME standardization. The table also shows that distinct levels of standardization occur as a function of the extent of aircraft modification. For example, if the aircraft is not modified for either a rear connector or cooling air, the maximum transition state that can exist for the avionics is low -- essentially only form, fit, and racking are implemented. If the aircraft is modified for either the connector or cooling air, a higher transition state occurs. PME standardization requires modification of both the LRUs and the aircraft for racking, connector, and cooling air to be fully effective.

Clearly, new aircraft and avionics designed to the new standards would serve to "pull" PME standardization into being, although taking several years to implement. Modification of existing avionics, primarily through Class IV modifications, could be implemented more quickly in some cases, or in a transitional mode in other cases. These modifications would serve to "push" PME standardization. In any case, the process of achieving full PME standardization throughout the Air Force could take two or three avionics generations; it will therefore require dedication and perseverance on the part of Air Force planners and managers.

6.3 SUMMARY

MIL-STD-XXX and -YYY have come a long way in their respective development cycles. XXX is close to embarking on the approval cycle, and YYY should be better defined and ready for forum discussions by late 1982. The major aspects of technical-issue resolution, standards approval, advocacy, and implementation approaches are reviewed in this section.

6.3.1 MIL-STD-XXX

Tests required to analyze LRU acceleration and shock, as well as connector mechanical and structural capabilities, should begin early in 1982 and be completed by mid-year. The development of a connector specification should proceed concurrently with testing of the ARINC-600 connector to prove its feasibility for military use. Both MIL-STD-XXX and the accompanying connector specification should be timed to enter the approval and coordination process with the technical issues sufficiently tested to permit them to be considered low risk. Given a concurrent program of education and advocacy, the approval process should yield completed, approved documents at about the end of 1983. The high-power addendum should also be included in the approval process as an adjunct to MIL-STD-XXX. Procurements advertised in 1983 could include draft MIL-STD-XXX, its addendum, and the connector specification as options or requirements for 1984-and-beyond purchases.

	Current Aircraft (No PME STD)	Current Aircraft (Partial PME STD)	Current Aircraft (Full PME STD)	New Aircraft (Full PME STD)
Current Avionics (No PME STD)	No PME Standardization	No PME Standardization	No PME Standardization*	No PME Standardization*
Class IV Avionics (Employing Partial PME STD)	Low PME State**	Mid PME State†	N/A††	N/A††
Class IV Avionics (Full PME STD)	Low PME State	Mid PME State	Full PME Standardization	Full PME Standardization
Newly Developed Avionics (Full PME STD)	Low PME State	Mid PME State	Full PME Standardization	Full PME Standardization

NOTES: *Avionics without PME standards in these cases would require nonstandard installation.
**Low state is defined as installation with either LRU PME connector or air cooling operative without similar provision in aircraft.
†Mid-state is defined as installation with either PME connector or cooling air operative.
††Class IV avionics with full (not partial) PME standard would be installed in these cases.

Figure 6-3. PME STANDARDIZATION IMPACTS FOR VARIOUS LEVELS OF IMPLEMENTATION

6.3.2 MIL-STD-YYY

MIL-STD-YYY is acknowledged as a necessary standard, on the basis of the current and potential proliferation of cockpit instruments and control/display units, including CRTs. Since documentation of MIL-STD-YYY lagged behind that of MIL-STD-XXX, however, MIL-STD-YYY will continue to be six months to a year behind in the development and approval cycles. Progress during the second open forum on this standard was slow. Many questions were raised, and they should be resolved by mid-1982. An open forum to address a redraft of MIL-STD-YYY as a principal topic should take place late in 1982, with a subsequent forum, if required, in early to mid-1983.

Procurements advertised in 1984 for 1985-and-beyond purchases could include MIL-STD-YYY as an option or a requirement in the same fashion as MIL-STD-XXX.

6.3.3 Advocacy and Policy

A program to educate Air Force and appropriate joint service members on the objectives and benefits of PME standardization should be undertaken immediately and should run concurrently with the standards approval process for MIL-STD-XXX, -YYY, and its addenda and ancillary specifications. This effort should be undertaken in a fashion that first informs the uninitiated, then develops an understanding of any issues or concerns that they may raise, and finally provides answers and subsequent interaction to achieve widespread acceptance of the PME concepts and implementation plans. This activity should be accompanied by development and staffing of necessary direction to be included in Air Force Regulation 800-28; its AFSC and AFLC supplements; appropriate using commands' regulations; and a PMD to underwrite the standard's development, approval, and implementation activities.

6.3.4 Early Implementation Steps

We recommend a three-pronged approach to implementing the new standards. The standards would be incorporated for (1) new aircraft or aircraft receiving new avionics suites, (2) new avionics development programs, and (3) Class IV avionics modification programs. Each of these approaches achieves a different level of PME standardization, as shown in Figure 6-3. While all of the different levels of standardization do not achieve the full benefits of PME standardization, they do achieve varying degrees of transition, which could eventually provide full PME standardization after two or three avionics generations.

In any case, we recommend that the selection of candidate aircraft and avionics for PME standardization be based on careful planning, data collection, and conduct of cost/schedule/performance trade-offs for each of the three areas discussed.

CHAPTER SEVEN

SUMMARY

Detailed recommendations have been included as appropriate in the discussions presented in the preceding chapters of this report. In this chapter, we summarize the status of the PME project and the actions needed to continue progress toward effective avionics standardization.

7.1 AVIONICS BAY INSTALLATIONS (PER MIL-STD-XXX)

Industry has supported the general PME concept. There are four major areas to be addressed:

- Validation of the rear connector concept and its hardware implementation
- Validation of the performance of the cooling air options
- Preparation of a MIL-SPEC for the connector
- Advocacy and support for the PME concept through the MIL-STD-XXX military coordination cycle

There is an objective to include in MIL-STD-XXX additional guidance material directed toward bringing high-power-dissipation LRUs into the standardization program also.

Prototyping and test programs should be planned and initiated without delay, to provide supporting hardware experience and design data.

7.2 MULTIFUNCTION DISPLAYS

The currently employed custom-designed multifunction displays, tailored to individual fighter-attack aircraft cockpits, provide a form and fit data base from which a range of standard sizes could be selected. Close attention is required, however, to the new concepts in fighter aircraft cockpit design that are currently developing.

Transport aircraft standards would be subject to different constraints and should be developed in parallel with commercial aircraft standards.

7.3 STANDARD INSTRUMENTS

Current standards for conventional instruments need some review. It would also be desirable to select fewer styles, applicable to the new role of standby instruments -- i.e., instruments that provide back-up flight data to the pilot in the event of a failure in the multifunction display system. At the same time, power-dissipation limits and cooling standards should be determined for the selected instrument types.

7.4 CONTROL AND DISPLAY PANELS

This group of equipment includes active LRUs, such as the AN/ARC-164 UHF transceiver and the AN/APX-100 IFF transponder, that are packaged to MS 25212. This standard requires additional definition of power-dissipation limits and a cooling interface that is compatible with the environment and cooling system of the cockpit.

APPENDIX A

OPEN FORUM ATTENDEES

Table A-1 lists the attendees at the second open forum, with their affiliations and working group memberships.

Table A-1. ATTENDEES AT SECOND OPEN FORUM							
Name	Affiliation	Working Group Membership					
		ARINC-600 Addendum	Control Display	Envi-ronment	Form and Fit	Con-nector	High-Power Addendum
C. B. Anderson	Sperry Flight Systems			X			
J. Andres	USAF ASD/ENAID		X				
G. Babb	USAF AFALD/PTSP				X	X	
S. Baily	ARINC Research Corporation				X		
J. Bair	USAF ASD/ENFSL			X			
P. Baris	Fairchild Republic				X	X	
W. B. Barrus	IBM, Manassas		X				
J. Bennett	Harris Government Systems				X		
R. Berger	ASD/ENFE	X		X			
B. Bernstein	Sperry						
R. Berthot	NAVAIR		X				
W. S. Boronow	McDonnell Douglas	X		X			
B. Brumm	Bendix Air Transport		X				
R. Climie	ARINC - AEEC	X					
V. Cirrito	Grumman			X			
G. Coker	Litton AMECOM				X		
B. Criscenzo	Bendix Communications				X		
B. W. Davis	Rockwell Collins			X			
E. Delgado	USAF PTE				X		
W. Detert	USAF ASD/ENES			X			
M. Donegan	IBM Corporation, Owego			X			
B. Eaton	Electrospace Systems			X			
D. T. Engen	Bendix Avionics	X					
M. Evans	AMP, Inc.				X	X	
D. Featherstone	ARINC - AEEC	X					
J. Franklin	Boeing Aerospace Corporation				X	X	
R. Grimm	Naval Air Test Center					X	
W. Gully	General Motors - Delco		X				
G. Hagman	Simmonds Precision		X		X		X
D. Harton	Bendix Communications				X		
J. Hoelz	Bendix Air Transport	X		X			
R. Hollingshead	Hollingshead International				X	X	
R. Horton	Westinghouse				X		X
P. Hurford	McDonnell Douglas				X		
R. Ittelson	USAF ASD/XRE	X					
J. Johnson	USAF - SA/ALC				X		
B. Jones	USAF ASD/ENO				X		
J. Kidwell	Naval Avionics Center				X		
M. Kocin	TRW Systems			X			
T. Kramer	Boeing Aerospace			X			

(continued)

Table A-1. (continued)							
Name	Affiliation	Working Group Membership					
		ARINC-600 Addendum	Control Display	Envi-ronment	Form and Fit	Con-nector	High-Power Addendum
Col. Larimer	OSD DMSSO						
B. Lijoi	Grumman				X		
T. Logan	Rockwell International, NAAD			X			
J. Maguire	ARINC Research Corporation					X	
J. Marcin	Douglas Aircraft		X				
A. Mondo	General Electric Company				X		
M. Moore	ITT Cannon				X	X	
S. Munson	ARINC Research Corporation			X	X		
T. Olsen	E-Systems, Greenville		X	X			
D. Palmer	Rockwell Collins		X				
J. Parks	Sperry Flight Systems		X				
J. Pizzuto	Singer Kearfott			X			
J. Price	Honeywell			X			
M. Prisant	Mod-A-Can, Inc.		X				
M. Ralph	USA ERADCOM			X			
E. Ramirez	Grumman			X	X		
D. Reeves	OSD/DMSSO						
James Reilly	Mitre Corporation			X			
John Reilly	USA ERADCOM			X			
K. Ricker	USAF						
J. Rickrode	AMP, Inc.				X	X	
R. Robinson	Barry Controls			X			
S. Sadja	Bendix Avionics	X					
A. Savisaar	ARINC Research Corporation		X	X			
A. Schimmel	Hollingshead International				X	X	
Maj. Schopf	USAF ASD/XRS						
L. Schwartz	ITT Cannon				X	X	
J. Silva	Hollingshead International				X		
N. Smith	ARINC Research Corporation				X		
D. Snell	Boeing Aerospace Corporation						
J. Steele	Masterite Industries						
E. Straub	ARINC Research Corporation		X				
H. Sullivan	ARINC Research Corporation			X	X		X
A. Tirums	Applied Technology, Sunnyvale			X			
J. Turner	General Dynamics				X		
J. Verdier	USAF ASD/ENASA			X	X		X
R. Vokits	USAF ASD/AXT		X				
O. Wendel	Lockheed						
J. Wilkinson	IBM Corporation			X			
K. Yada	ITT Cannon				X	X	

APPENDIX B

LABORATORY REPORT: STRUCTURAL TESTS ON LRU/CONNECTOR/RACK MECHANICAL ASSEMBLY

1. OBJECTIVE

Tests were performed to provide preliminary information on the structural behavior of the proposed MIL-STD-XXX LRU and rack assembly, under the steady acceleration loads specified for military aircraft application. The following structural members were involved in the tests:

- Mounting Tray (Modified Backplate) (Part Number 606-2706-062)
- ARINC-600 Size 2 Plug and Receptacle
- Jack Screws (two) (Part Number 245-100-1T)
- Holddown Hooks (two) (Part Number NAS-622-T1)
- Dummy LRU - Size 6 with Loading Attachment

2. METHOD

A good indication of the behavior of the members of a structural assembly under stress loading is given by stress-versus-strain relationships -- the stress being a measure of the loading as it is incrementally applied and the strain being a measure of the overall deformation of the structure. When the nature of the deformation is observed, multiple strain measurements can be made at critical points (or components) in the structure.

3. TEST CONFIGURATION

3.1 Dummy LRU

A dummy size 6 LRU shell was fabricated from aluminum sheet. The backplate of the LRU was pierced to accommodate the ARINC-600 size 2 receptacle. The frontplate was fitted with NAS Type 622-T1 hooks. A loading bar was secured along the centerline of the dummy LRU, with 1/4 inch aluminum plate bulkheads to transfer load to the LRU shell. Each of the four long faces of the LRU was pierced with a 3-inch-diameter hole to give access for loading the bar. Endwise loads were applied directly to the frontplate and backplate of the dummy LRU.

3.2 Mounting Base

A rigid mounting base was constructed from structural steel beam and plate to form a solid mounting base that could be set up in various orientations within the frame of a hydraulic press. The plate was pierced with 1/4 inch clearance holes so that the LRU traymount could be attached in two optional directions.

3.3 Traymount and Holddown Fasteners

A production traymount, with its backplate modified in accordance with the proposed cooling-air aperture configuration, was attached to the heavy mounting base by oversize (1/4 inch) bolts, nuts, and washers to prevent premature failure of the tray-to-structure attachment (which was not required to be subject to test). The traymount included its regular floating spindle holddown/extractors.

3.4 Connector

The connector receptacle was installed in the dummy LRU by means of its specified ten size 6/32 screws and nuts. The connector plug was installed in the tray by means of its specified eight size 6/32 screws and nuts. After the second test, the plug was reinforced with a machined backplate, attached via the ten mounting holes with size 6/32 screws and nuts.

3.5 Test Assembly

Figure B-1 shows a typical setup, testing for negative g (downward acceleration/upward reaction force) by inverting the test assembly in the press. Figure B-2 shows the functional components of the test setup. In sequence from the top are the following:

Hand Pump Valve Hydraulic Ram Manual Screw	Dake Press: Model 504
Centering Ball Force Gauge	Dillon Compression Gauge, Model 500 5 lb/div. 1,000-pound Capacity (2 turns), SN 15274
Thrust Member	--
Load Bar	--
Dial Gauge	Brown & Sharpe 8241-942, 1.000
Baseplate	--

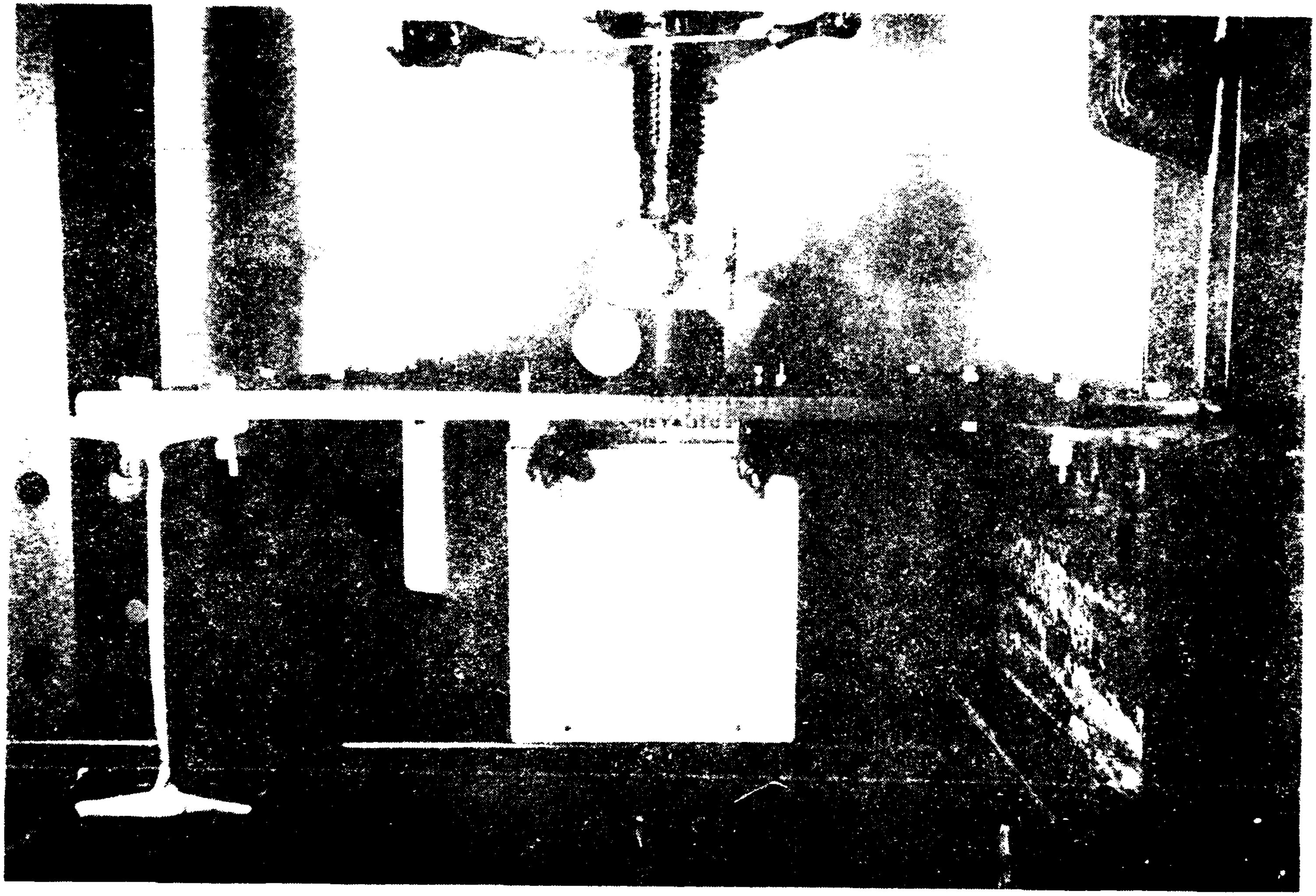


Figure B-1. TYPICAL TEST SETUP

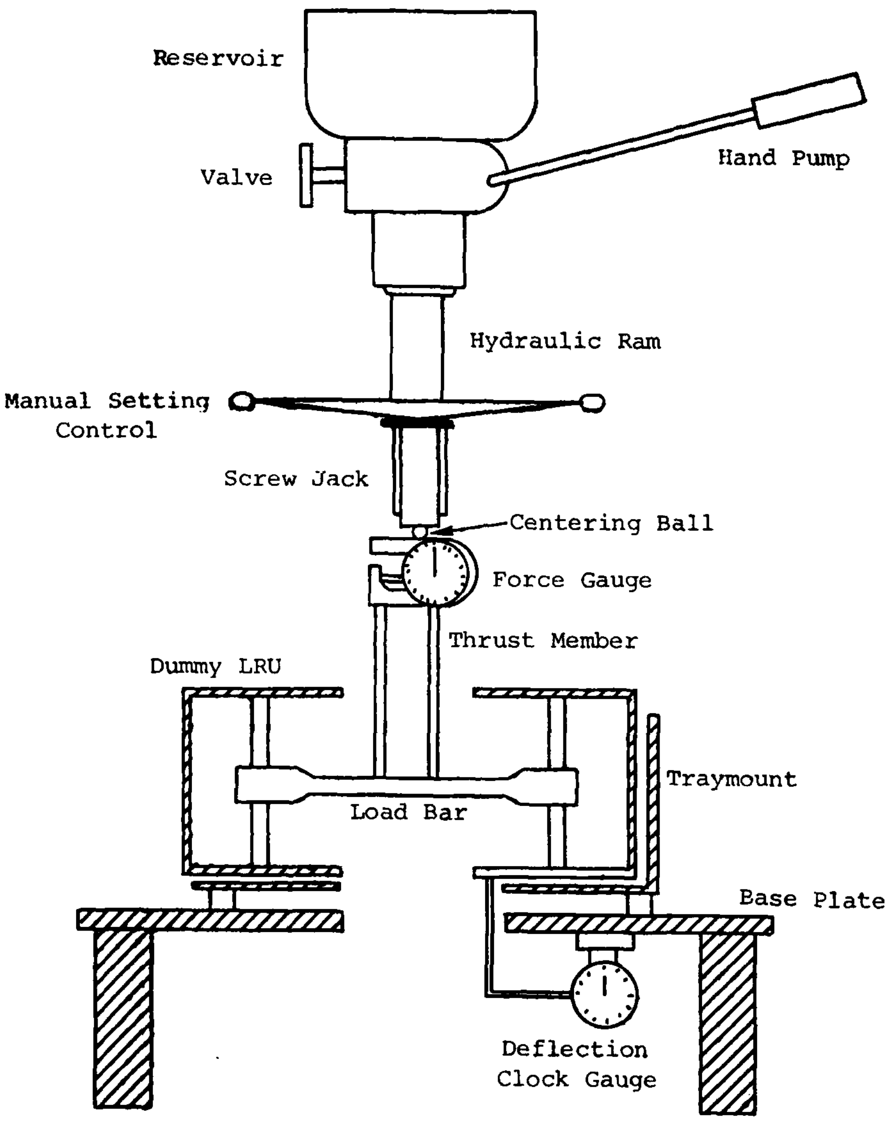


Figure B-2. TEST SETUP COMPONENTS

4. TEST PROCEDURE

4.1 Calculation of Load Values

The tests required the simulation of acceleration loads in excess of normal gravity by the maneuvering g factors specified. The maximum allowed weight (at 1 g) of the size of LRU that was simulated is 52 pounds. The actual weight of the dummy LRU was less than 9 pounds and was neglected. The test loads for the size 6 LRU were calculated as shown in Table B-1.

Table B-1. ACCELERATION TEST LOADS

Test Direction (Force Relative to Normal Upright Orientation)	Acceleration Factor	Calculated Test Load (Pounds)	
		"No Damage"	"No Release"
Up	4.1	213	320
Down	10.4	541	811
Left	6.1	317	476
Right	6.1	317	476
Inward	6.1	317	476
Outward	6.1	317	476

The same connector and holddowns may also be used on the largest (size 12) LRU, which can weigh 90 pounds, and an "inward" shock load on the connector has been specified at 1,000 pounds, representative of rough insertion of an LRU into its tray. Preliminary testing at the 1,000-pound level was therefore included for the inward, outward, and downward test directions.

4.2 Setting Up

For each loading condition, the test assembly was set up with the centering ball trapped between the recess in the face of the screw jack member and the recess in the top of the force gauge. The gauge was positioned centrally on top of the thrust pipe, which was seated centrally on the square section of the load bar. The position of the mounting base was trimmed until the thrust pipe was vertical and in line with the screw jack. It was then clamped firmly in that position. The dial gauge was then clamped to the mounting base and set to show the vertical displacement of the shell of the dummy LRU from its initial "no load" condition.

4.3 Data Measurement

Thrust was applied to the press either by operating the hydraulic wobble pump or by closing the shut-off valve (to lock the jack) and readjusting the screw setting wheel by hand. After each 50-pound increment of stress had been set up, the deflection gauge reading was checked for stability and its value recorded.

4.4 Test Results

The test results are plotted as stress/strain relationships in Figures B-3 through B-10, showing repeated cycles of test as appropriate. The mechanical hysteresis of the assembly and any permanent (or progressive) set was estimated and included in the summary table, Table B-2.

On the second test, the lower mounting flange of the connector plug fractured (see Figure B-11). This failure is analyzed in Section 5 of this appendix. To permit continuation of the testing, the broken connector was remounted on a rigid machined backplate and reassembled into the tray. Such reinforcement is representative of the redesign necessary for military applications of the connector; but this "fix" was certainly overconservative, so that runs 3 through 8 did not test the connector plug. They did test the receptacle, however, and on run 8 (which repeated run 2) the receptacle failed -- again, at the lower flange (see Figure B-12).

Table B-2. ACCELERATION-LOAD TEST RESULTS

Test Number and Direction	Cycle	Applied Load (Pounds)	Deflection (Inches)	Incremental Set (Inches)	Total Set (Inches)	Estimated Mechanical Hysteresis (Inches)
1. Downward	1	1,000	.054	.010	.010	---
2. Into Tray	1	500	.110	Plug fractured just before 520-pound load was reached.		
3. Left Side	1	320	.068	.018	---	
	2	320	.069	.002	.020	.012
4. Upward	1	220	.077	.004	---	.023
	2	220	.084	.001	.005	.012
	3	320	.123	.009	.014	.026
5. Out of Tray	1	320	.111	.003	---	.040
	2	220	.084	-.001	.002	.025
6. Right Side	1	320	.051	.008	---	.006
	2	220	.041	.00	.008	.006
7. Downward	1	320	.036	.008	---	.002
	2	220	.030	0	.008	.004
8. Into Tray	1	500	.063	Receptable fractured just before 520-pound load was reached.		

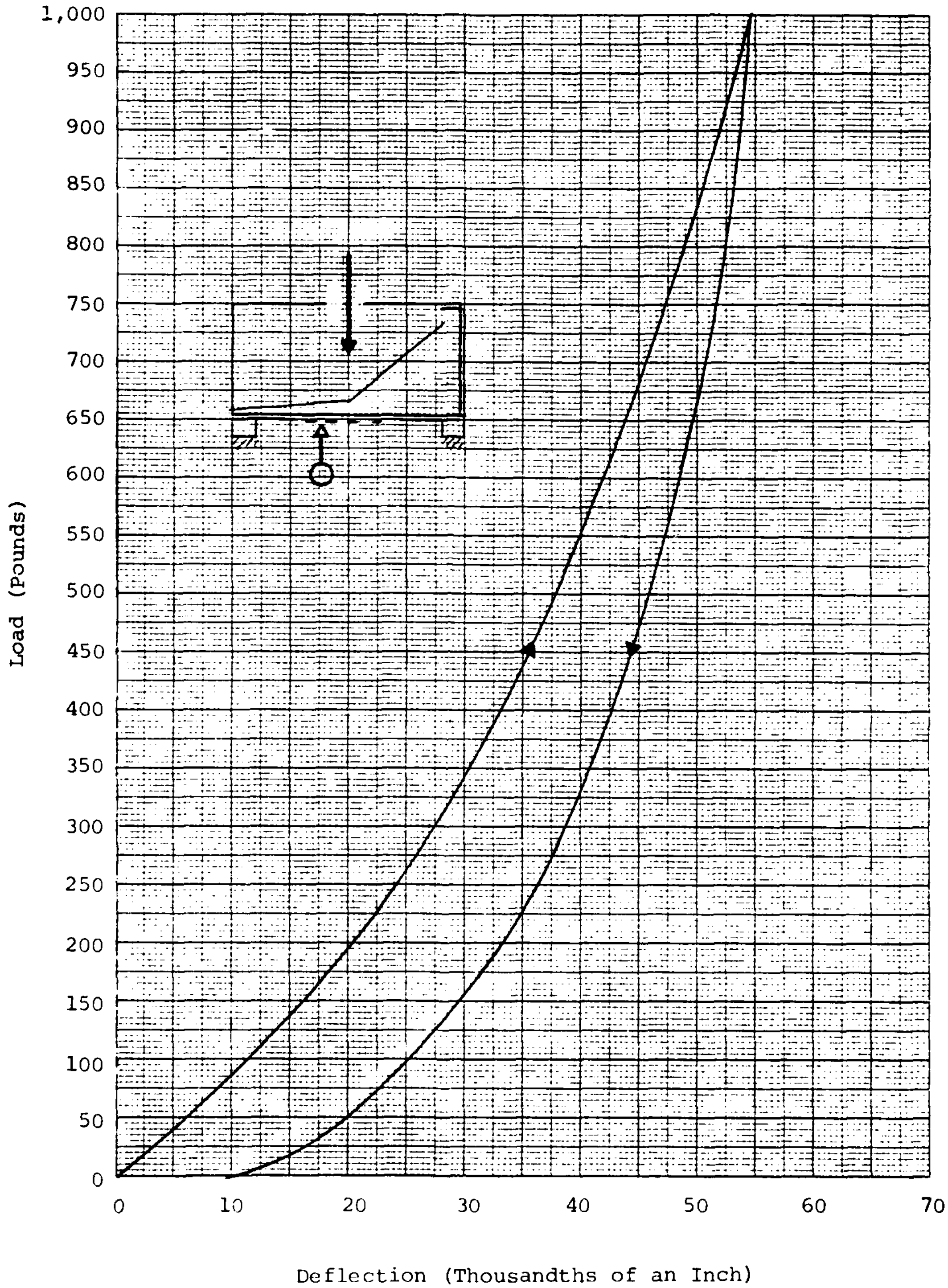


Figure B-3. STRESS/STRAIN RELATIONSHIP, TEST 1

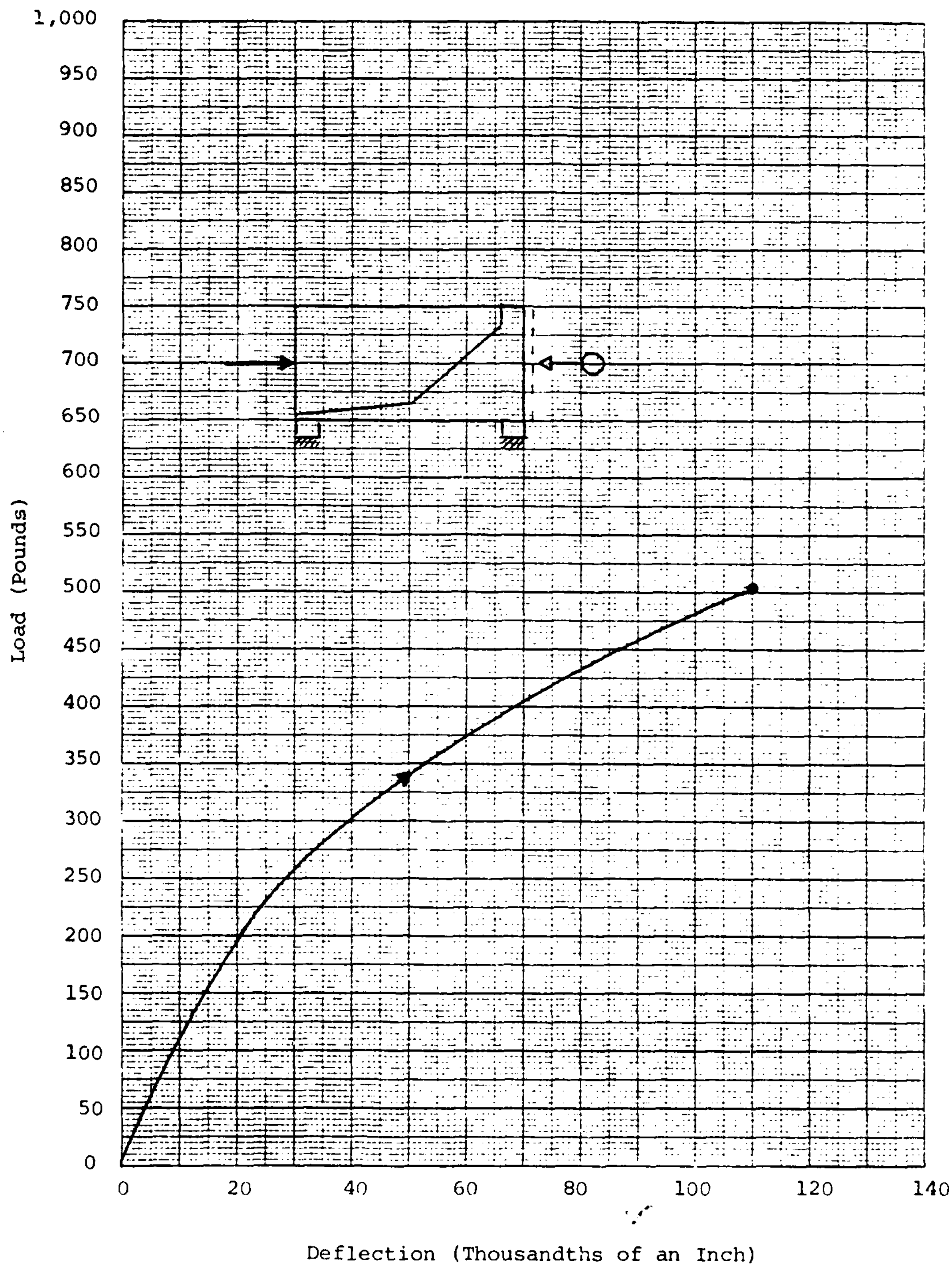


Figure B-4. STRESS/STRAIN RELATIONSHIP, TEST 2

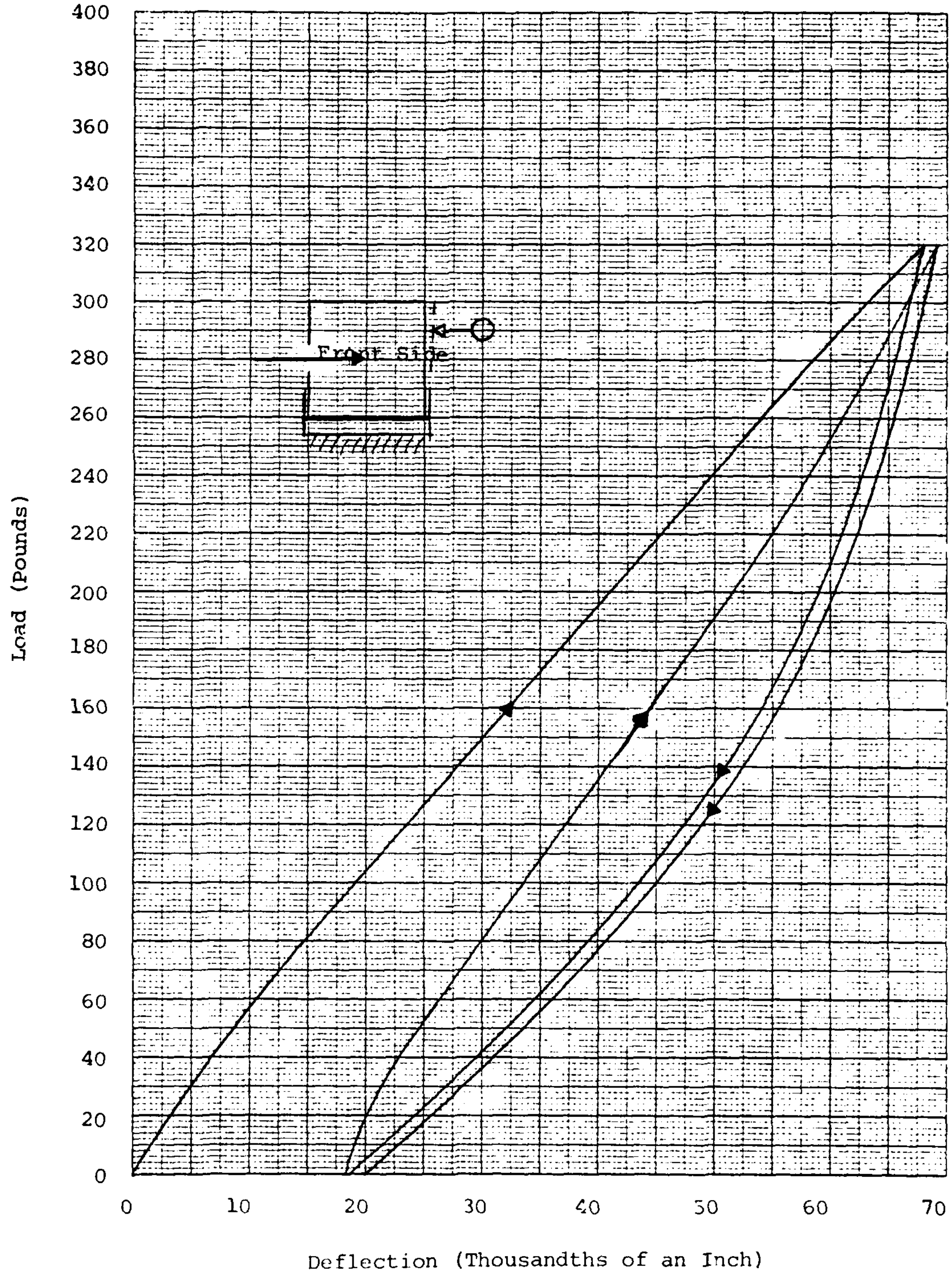


Figure B-5. STRESS/STRAIN RELATIONSHIP, TEST 3

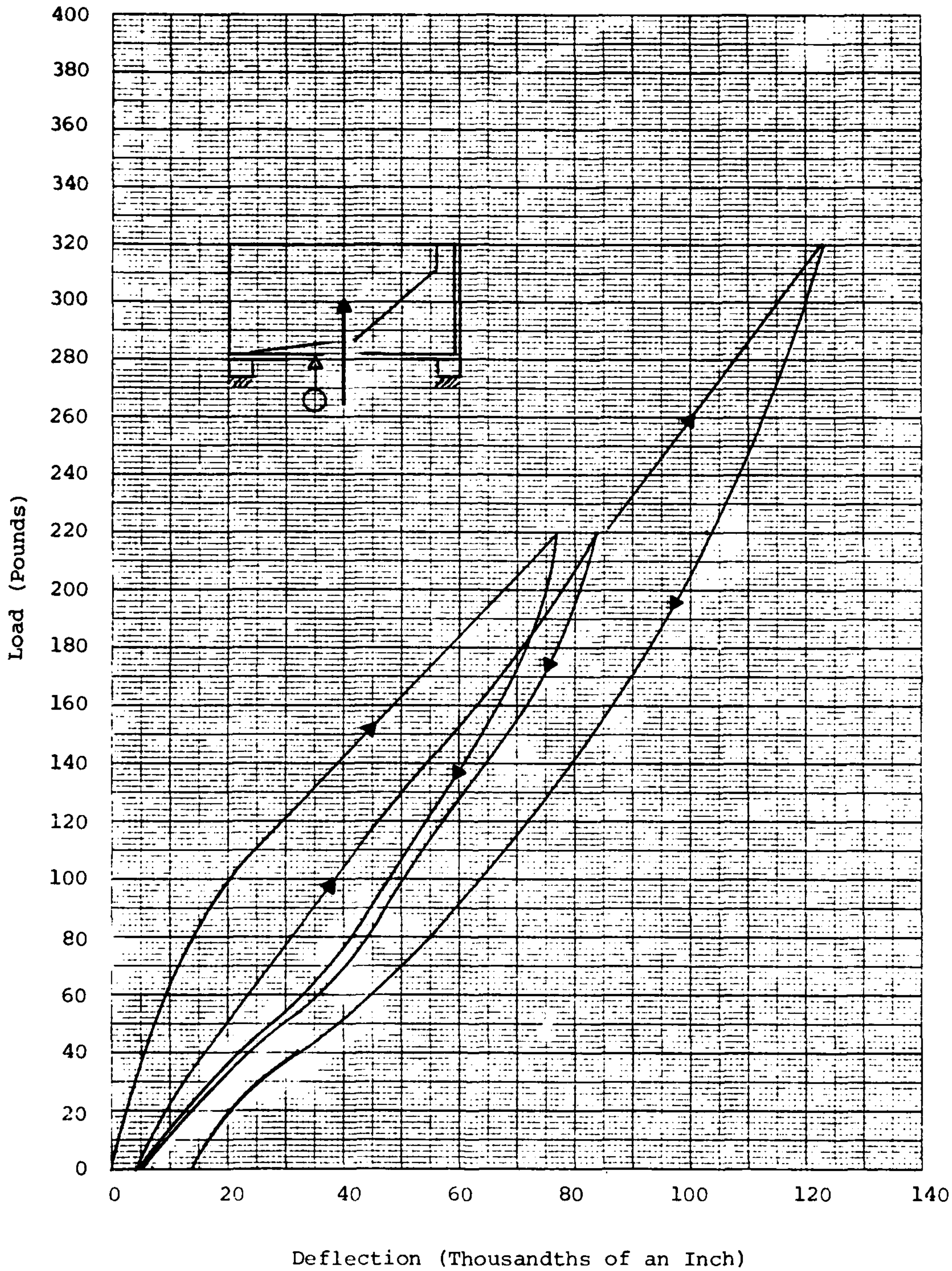


Figure B-6. STRESS/STRAIN RELATIONSHIP, TEST 4

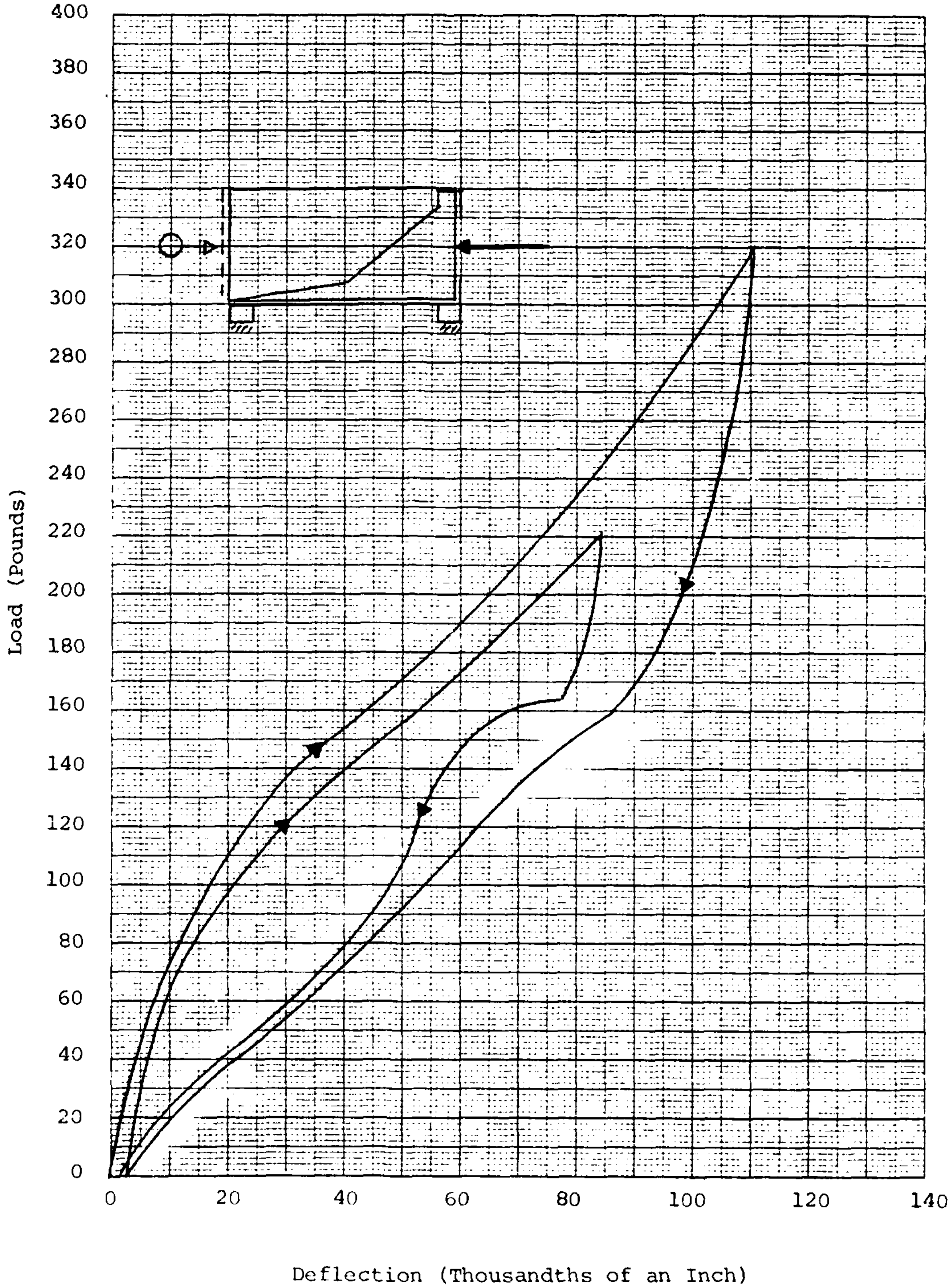


Figure B-7. STRESS/STRAIN RELATIONSHIP, TEST 5

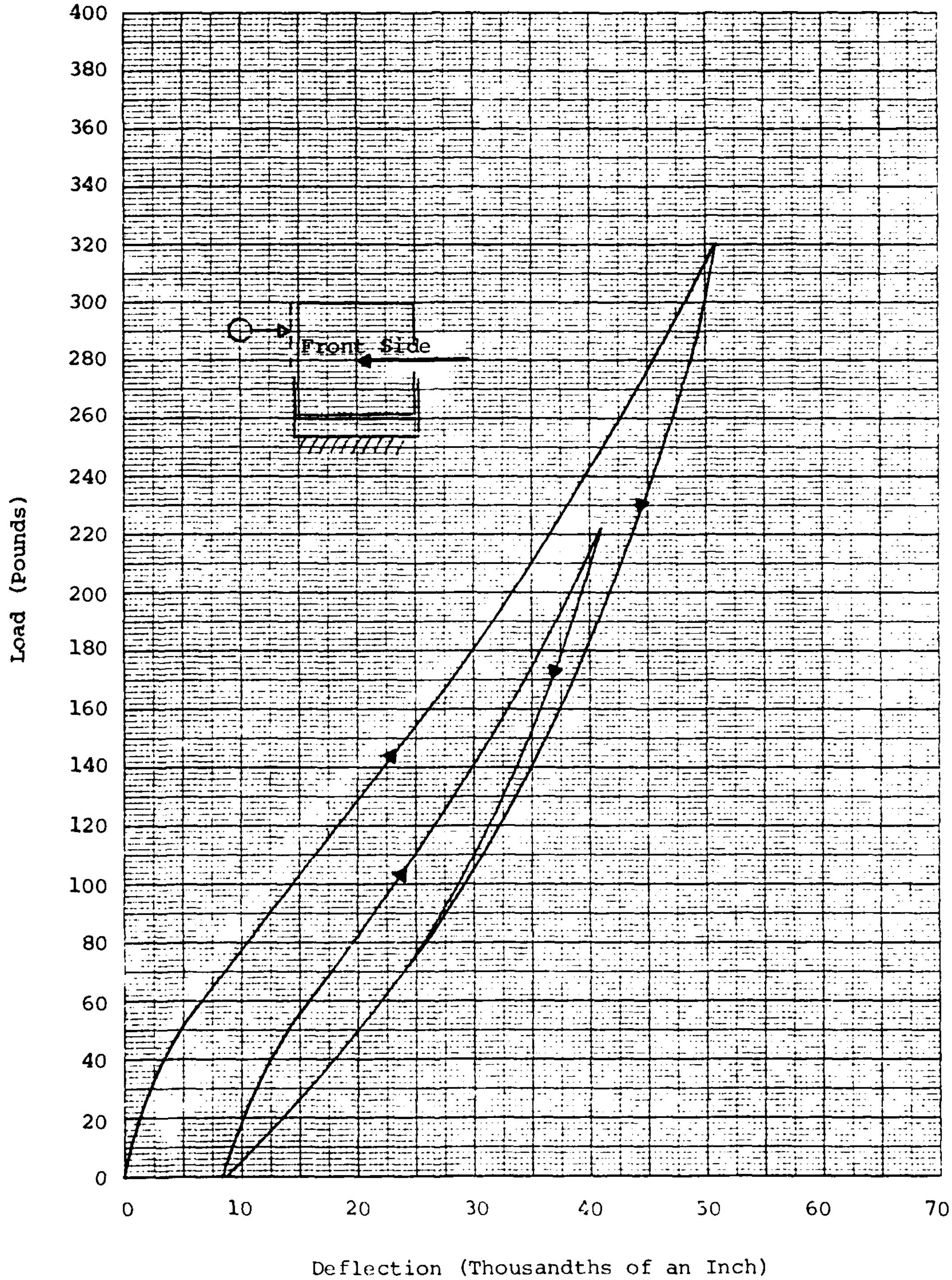


Figure B-8. STRESS/STRAIN RELATIONSHIP, TEST 6

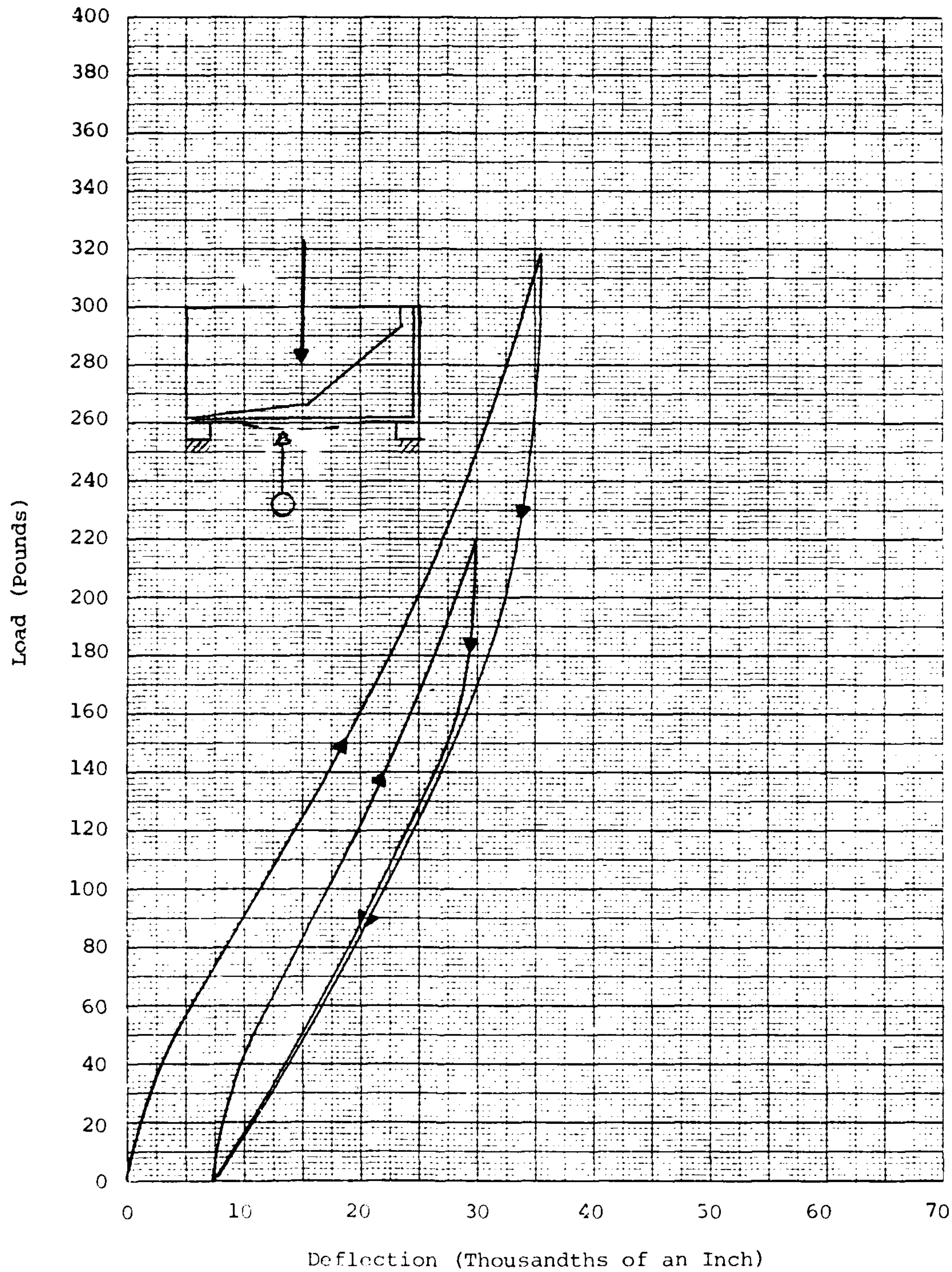


Figure B-9. STRESS/STRAIN RELATIONSHIP, TEST 7

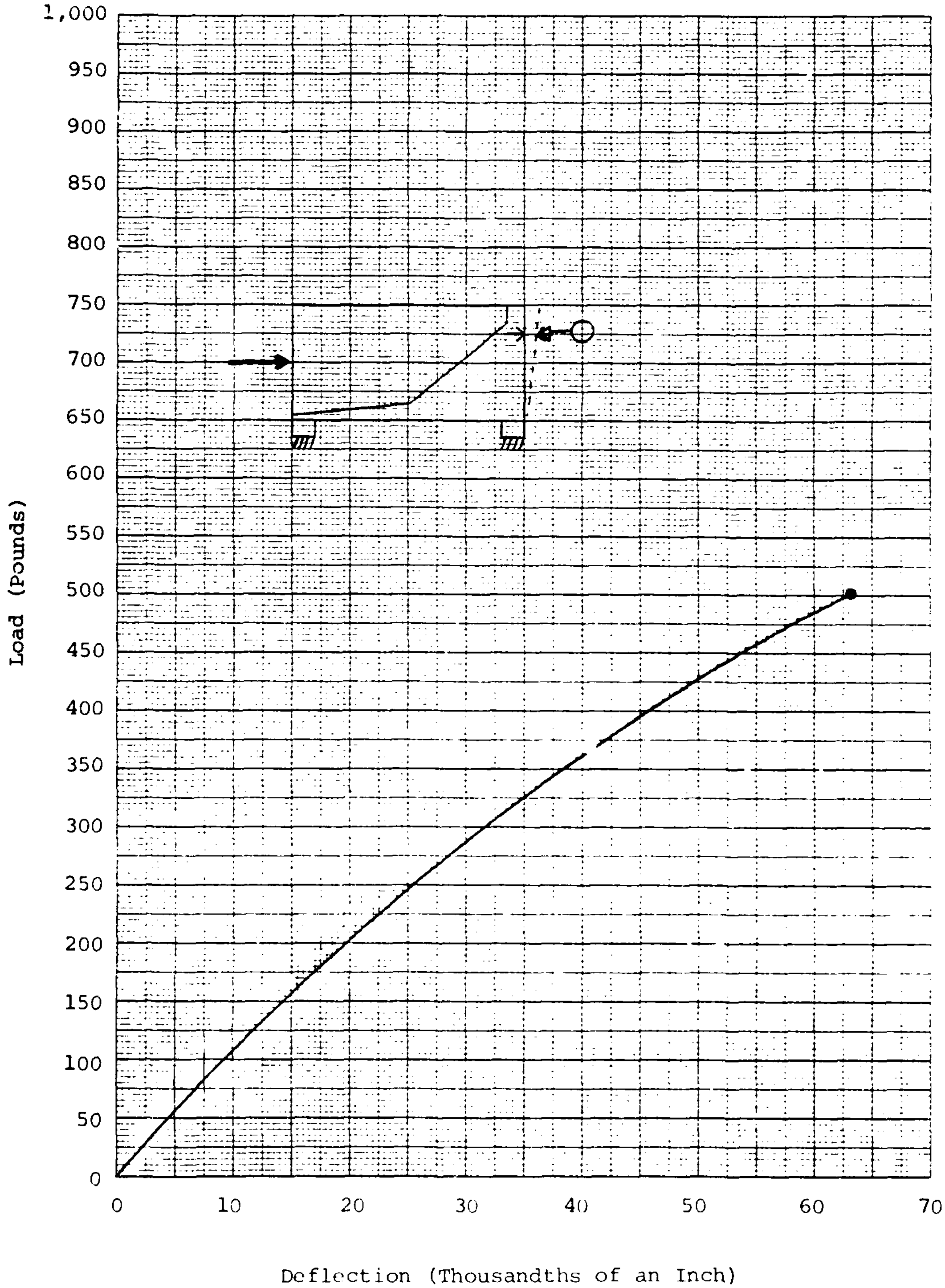


Figure B-10. STRESS/STRAIN RELATIONSHIP. TEST 8

AD-A116 853 ARINC RESEARCH CORP ANNAPOLIS MD F/G 1/3
DEVELOPMENT OF AVIONICS INSTALLATION INTERFACE STANDARDS.(U)
DEC 81 C N SMITH, N SULLIVAN, A SAVISAAR F04606-79-G-0082
UNCLASSIFIED 2258-21-3-2595 NL

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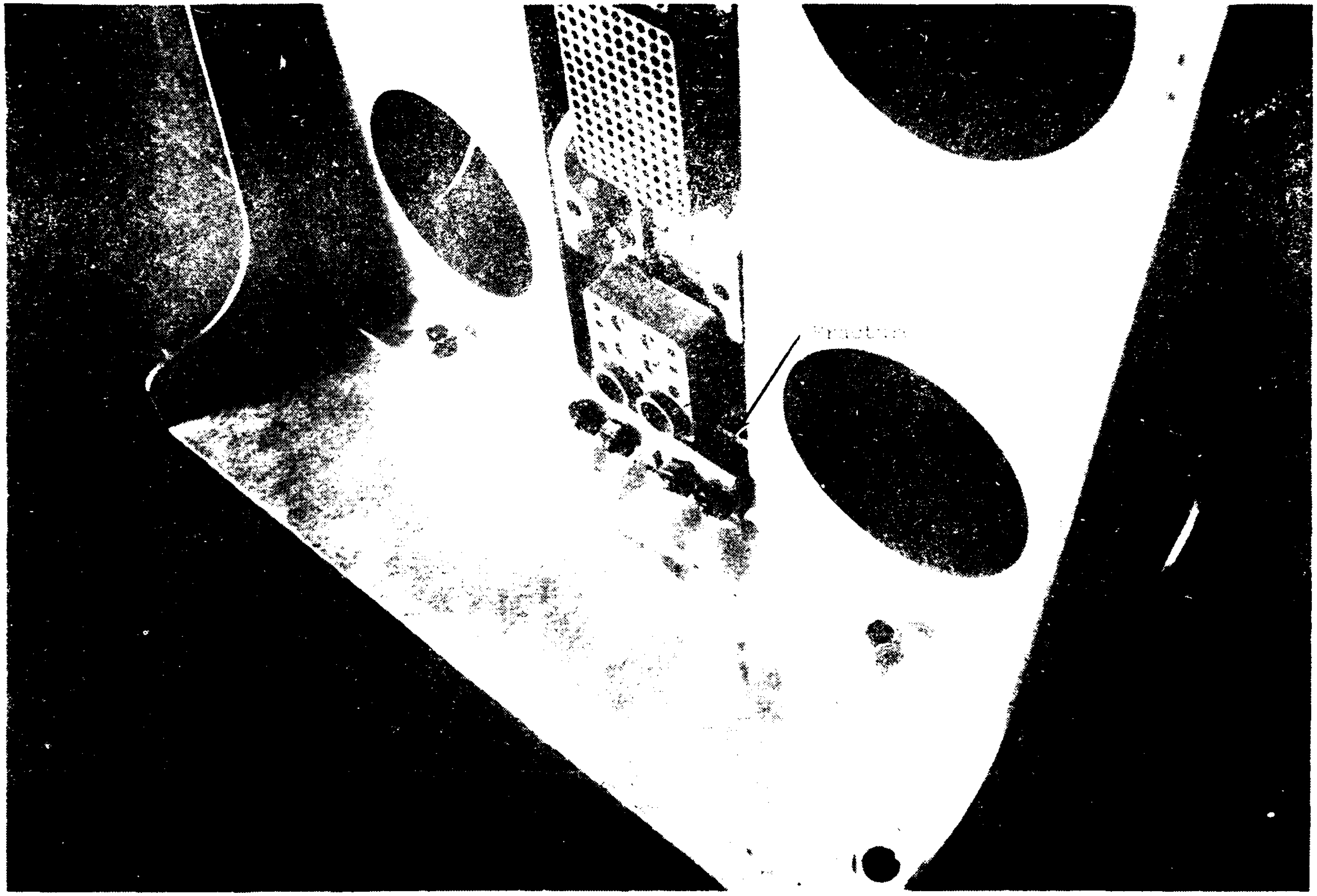
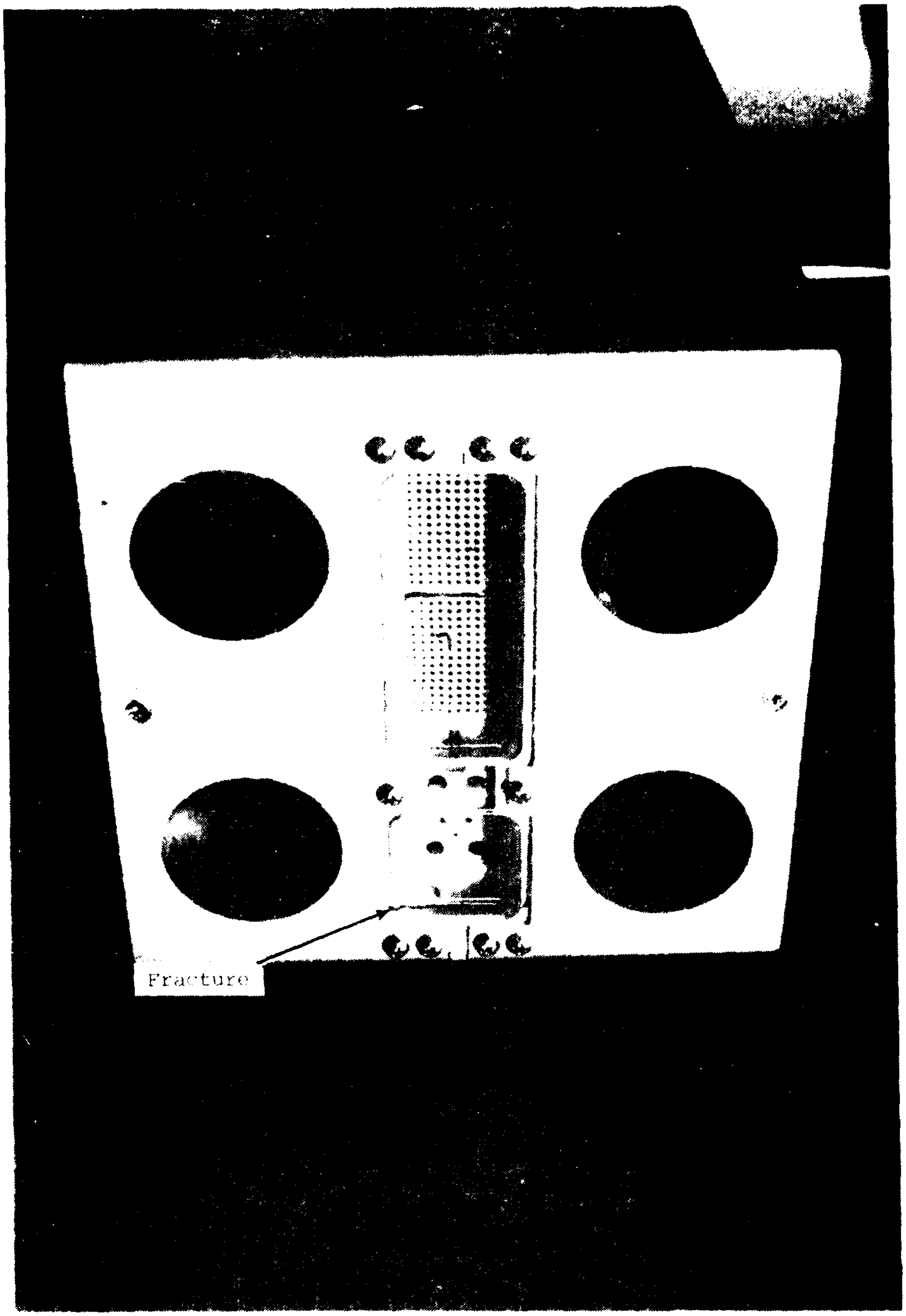


Figure B-11. CONNECTOR PLUG FRACTURE


Fracture

5. ANALYSIS OF FAILURES

5.1 Materials

The aluminum connector shells are diecast in Alloy A380, copper silicon alloy. At room temperature, the tensile strength is listed as 42,000 psi; 0.2 percent yield strength is listed as 21,000 psi.

The tray assembly is manufactured from 0.063 inch aluminum alloy sheet 6061-T6 condition. The backplate of the tray is draw-formed. The dummy LRU was fabricated from 0.090 inch aluminum alloy sheet 6061-T6, the top, bottom, and rear surface being bent from one strip. The tensile strength of 6061-T6 alloy is listed as 45,000 psi; 0.2 percent yield strength is listed as 40,000 psi.

5.2 Failure Mode and Dimensions

The fractured flanges, Figures B-11 and B-12, both occurred at an "into the tray" loading of 500 pounds. These failure modes are best illustrated by the force and reaction diagram of Figure B-13.

The connector plug and receptacle fit together when the LRU is inserted into the rack and are fully engaged when the metal shell of the plug bottoms in the metal shroud of the receptacle. There is positive clearance of 0.003 to 0.007 inch all around, which is taken up by a recessed "O" ring seal. The whole load force in the direction "into the tray" is transmitted through connector shells. The connector plug and the backplate on which it is mounted are cantilevered off the base of the tray so that the upper parts of this assembly can yield more readily than the lower part, leaving the larger part of the load force to be reacted at the point C. We assumed that the load is shared 25 percent at the top and 75 percent at the bottom of the connector.

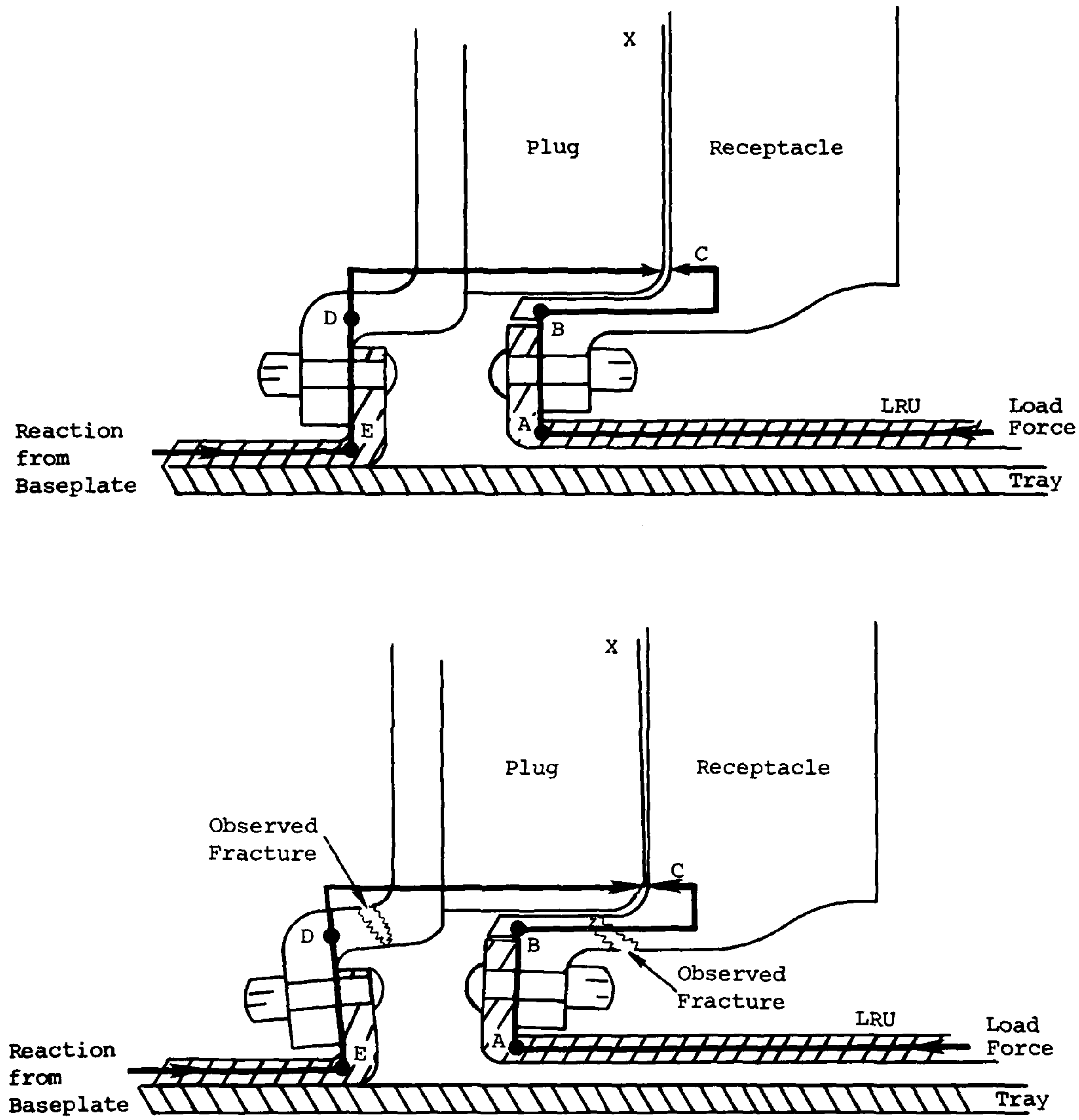
The path of this force is illustrated by the sequence of points A, B, C, D, and E, where B and D are to be located at the observed points of fracture. The bending moments (M) at points A, B, D, and E are easily calculated from the dimensions shown in Figure B-13:

- At A and B, $M = 375 \times 0.741 = 278$ pounds inches
- At D and E, $M = 375 \times 0.844 = 317$ pounds inches

The modulus of section at each of these points that is available to resist bending must be estimated from the formula $m = \frac{bd^2}{6}$, where b is the width of the flange and d is its thickness.

The maximum tensile stress at the surface of the part can now be calculated:

$$S_{max} = \frac{M}{m} = \frac{6M}{bd^2}$$



Dimension AB = 0.741 in.
Dimension ED = 0.844 in.
(center to center of material)

Figure B-13. LOAD FORCE AND REACTION DIAGRAMS

Point	b (inches)	d (inches)	m ($inches^3$)	S_{max} (lb/in.^{2})
A	2.7*	.090	.0036	77,000
B	1.8	.125	.0047	59,000
D	1.6	.125	.0042	75,000
E	2.4*	.063	.0016	198,000

*The effective width of the sheet metal flange is assumed to be 1.5 times the length of the mating part.

Points B and D are "hard," being composed of diecast material with an elongation of 3 percent as compared with the "soft" sheet stock elongation of 12 percent. Thus, in Test 2, yield occurred at point E, followed by failure at D; and with these points reinforced in Test 8, yield occurred at Point A, followed by failure at Point B.

5.3 Conclusion

The mounting configuration of the connector relies too much on the stiffness of the supporting structure. While reinforcement of the sheet metal structure can alleviate the bending stresses transferred to the connector shells, a preferable resolution would be to reconsider the connector flange design to make it less vulnerable to bending moments.

APPENDIX C

TABULATION OF CHANGE REQUESTS (MIL-STD-XXX) AND CHANGES MADE

Table C-1 lists the principal points of discussion that resulted in proposed changes to MIL-STD-XXX, together with the requester's name, an outline of the resulting change, and the working group chairman's comments.

These changes have been incorporated into the December 1981 draft MIL-STD-XXX, Attachment 1 to this report.

The reference numbers shown in the first column are the serial numbers of the individual change request forms used at the second open forum to record suggested changes to the draft standard.

Table C-1. TABULATION OF CHANGE REQUESTS			
Reference and Subject	Requester	Change Made With Rationale	Chrirman's Comment and Paragraph Affected
1, 23 Cooling Air Flow Rates	V. Cirrito J. Bennett	Figure 14 replotted on linear scales for 71°C air exit temperature	Concur, 5.5.4.2
2 and 10 Other Environmental Requirements	M. Donegan J. Kidwell	Paragraphs 5.1.6 and 5.2.5 brought into line with MIL-E-5400T, paragraph 3.2.2.4, and referenced thereto.	Concur, 5.1.6, 5.2.5
3 Clarify Wording	V. Cirrito	Added wording incorporated, as requested.	Concur, 1
4 and 17 Ambient Temperature	J. Pizzuto	(a) "non-operating" and (b) "95°C at sea level" added, (c) "-54° to 71°C added."	Concur, 5.5.3
5 Pressure Drop Through LRU	M. Donegan	Requested changes incorporated.	Concur, 5.1.2.1
6 Pressure Drop Through Rack	J. Pizzuto	Requested sentence added.	Concur, 5.2.3.2
7 Add Test Conditions	J. Pizzuto	15.5°C air temperature and sea-level pressure specified.	Concur, 5.5.4.3
8, 25, 56 Air Inlet Configurations	J. Pizzuto	Drawings revised. See also 42, 43, 47, 52, and 65.	Further study needed, Figures 1, 3, 6, 8, 9
9 Drain Holes	Brad Davis	Drain-hole requirement, new paragraph added.	Concur, 5.1.2.4
11, 17 Loss of Cooling Air	V. Cirrito J. Pizzuto	Clarification incorporated. 30-minute limit added: "(a) Loss of *Cooling* Air Supply: LRU shall perform and survive 10 minutes operation. (b) Emergency Ram Air Cooling: LRU shall perform and survive 30-minute operation."	Concur, 5.1.4, 5.5.3
12 Documents List	M. Donegan	MIL-E-5400T referenced and put in document list. MIL-STD-210B put in document list as background information.	Concur, 5.1.6, 5.2.5, 2.3
13, 58 Junction Temperatures	W. O. Detert J. Kidwell	Junction temperature table replaces old wording.	Concur, 5.5.2
14 Vibration Test	J. A. Bair	Commentary changed as requested.	Concur, 5.2.5.1
15 Connector Testing	A. T. Tirums (Applied Technology)	MIL-E-5400 shock-load requirement added.	Concur, 5.3.2
16 Thermal Design	R. Berger	Design conditions 15.5°C and 40°C bulk air inlet temperature. Coolant flow rates per Figure 14.	Concur, 5.5.4.1, 5.5.4.2

(continued)

Table C-1. (continued)			
Reference and Subject	Requester	Change Made With Rationale	Chairman's Comment and Paragraph Affected
18, 19, 27 Vibration Specification	J. A. Bair J. Pizzuto	Incorporated in new "Service Conditions" paragraph.	Concur, 5.1.6.4 (new paragraph)
20 Cooling-Air Transient Temperatures	V. Cirrito	Change (a), (b), and (c) to: Transient - 54°C to 71°C (10 minutes) Normal -54°C to 40°C (continuous)	Concur, 5.5.4.1
21 Thermal Design	W. S. Boronow	Change 80°C to 71°C.	Concur, 5.5.1(i)
22 Cooling-Air Leakage	M. Donegan	Requested wording replaces entire paragraph.	Concur, 5.5.4.4
24, 46 ECS Failure	J. Bennett A. Mondo	Automatic shutdown if cooling air supply fails.	Further study needed, 5.1.4
28 Load Factors	J. A. Bair	Wording changed as requested; levels not changed pending Air Force study.	Further study needed, 5.1.6.5
29 Mechanical Evaluation	J. A. Bair	Appendix II mechanical evaluation added.	Concur, 5.7 and new appendix
30 Sidwall Temperatures	B. Davis	Not adopted. Sidewall temperature limits apply to all LRUs. Heat will leak to cooler units, and this is simulated in test setup.	
31 Power Dissipation Limits	M. Donegan	Thermal dissipation of forced-air-cooled LRUs reduced to half.	Concur, 5.1.2.2
32 Thermal Evaluation	M. Donegan	Appendix I redrafted as per request; review/coordination needed.	Further study needed,
33 Thermal Evaluation	M. Donegan	Added wording as requested.	Concur, 5.5.6.2
34 Reliability Analysis	R. Berger	±25% replaces 50% and 150%. 15.5°C coolant entry specified.	Concur, 5.5.7(f)
35 Open Cooling Parts	P. Baris	Wording revised as requested.	Issue remains, 5.2.3.2
41, 48 Design Requirements in Interface Specification	D. Harton D. W. Snell	Military caucus determined that avionics internal design guidance and requirements should be part of this standard.	N/A
42, 43, 47, 52 Location of Connector	D. Harton J. Bennett J. L. Franklin D. W. Snell	See also 8, 25, 56, and 65. Drawings revised to center connectors.	Figures 1, 3, 6, 8, 9
44, 60 Connector Specification	B. Lijoi J. Wilkinson	Rework connector requirements to create a MIL-SPEC.	In work

(continued)

Table C-1. (continued)			
Reference and Subject	Requester	Change Made With Rationale	Chairman's Comment and Paragraph Affected
45, 57 Front-Connector Option	B. Lijoi J. Kidwell	Commentary added to provide requested option. Figure (from MIL-C-172) added. See also 57.	5.3.2, New Figure 12
49, 53 Dimensions and Tolerances	J. Bennett	Interface dimensions and tolerances to be reviewed.	Action ARINC
50 MIL-STD-1672 Handles	J. Bennett	MIL-STD-1472 handle requirements demand excessive front volume.	Issue remains
51, 54, 64 Sidehooks Option	J. Bennett J. Wilkinson G. Coker	Low profile sidehood provisions on sizes 2 through 5 will give a logistics advantage.	Issue remains
55, 59 Cooling-Air Inlets	P. Baris R. Horton	Cooling-air inlets above and below reduced-height connector.	Figures 1, 3, 6, 8, 9
61 Weight Limits	D. Harton	Weights Table: Weight limits of smaller LRUs reduced as requested.	Concur, 5.1.4.4
62 Liquid Contaminants	G. Hagman	"Other liquid" contaminant requirement added to connector paragraphs.	Concur, 5.3.3
63 Overweight Warning	G. Hagman	Requirement for overweight (human factors) warning label added.	Concur, 5.1.1.4
71 Dimensions and Tolerances	J. Rickrode	Datum and dimensioning review in work.	Action ARINC
72 Connector EMI	J. Wilkinson	Connector backshell/EMI filter concepts being worked by connector firms and G. Babb.	
73 Bonding and Grounding	D. Snell	Bonding provision - a uniformly acceptable concept is needed.	Guidance needed
74 Typographical Error	G. Babb	Typo. Corrected	Concur, 5.1.3.1.1
75 Size of Contacts	G. Babb	Size 22 identified with LIF signal contacts. Size 8 removed from power contact options. Note: power and coaxial contacts are conventional (i.e., not LIF). MIL-C-81659A reference deleted.	Concur, 5.3.1.1
76 Connector Attachment	G. Babb	Changed as requested. Option and dimensional note for back surface mounting put in commentary.	Concur 5.3.5.2

APPENDIX D

RECOMMENDED CHANGES TO *MIL-STD-YYY*

Table D-1 lists the specification changes recommended by the Air Force Second Avionics Installation Open Forum following the working group review of the August 1981 strawman Control and Display Unit Installation Standard (MIL-STD-YYY).

The working group recommended further review and study by ASD/EN before the strawman is updated and reissued.

Table D-1. CHANGES TO MIL-STD-YYY, OCTOBER 1981

Paragraph Number	Delete Following Words	Add Following Words	After (or Remarks)
1 (6), (7), (8)	Mechanical interfaces are not defined for controls and displays mounted on glare shields and side panels, usually unique to the aircraft type.		aircraft
1.a (2)	and its		equipment
1.b (3)	and		equipment
1 (25)		This specification does not cover the HUD installation requirements.	(New sentence following subparagraph c)
2		MIL-STD-1472B, 12/31/74, Human Engineering Design Criteria for Military Systems, Equipment and Facilities.	(New military standard)
2		MS 28042, 5/26/70, Clamp, Instrument Mounting, Aircraft	(New military standard)
2		MS 25212, 8/25/60, Control Panel, Console Type, Aircraft Equipment, Basic Dimensions.	(New military standard)
2		MIL-STD-454G, 3/15/80, and Notice 1, 8/29/80, Standard General Requirements for Electronic Equipment.	(New military standard)
3.1 (2)	. (period)	per Requirement 52 of MIL-STD-454 (excluding direct air impingement).	unit
3.1 (4)		Flow-by cooling is used when there is no room for other cooling and this is illustrated in Figure 6.	unit
3.1 (8)		Type D-Direct air impingement, when approved by the procuring activity.	(New Type D cooling)
4.1.2 (6)	three	four	defines
5.1 (4, 5)	Air Force.	user.	the

(continued)

Table D-1. (continued)

Paragraph Number	Delete Following Words	Add Following Words	After (or Remarks)
5.1.1 (8, 9)	Up 4.1 g, Down 10.4 g	Negative 4.1g, Positive 10.4g	Vertical axis:
5.1.1 (1)		5.1.2 <u>Crash Safety</u>	10.4 g (Add new title)
5.1.1 (15, (16)	up 6.15 g, down 15.1 g	Negative 6.15 g, positive 15.6 g	Vertical axis:
5.1.2 (1)	5.1.2	5.1.3	(Paragraph number change)
Figure 1, Page 4	Figure 1 illustration	Figure 10 illustration from MIL-STD-XXX	
5.1.4 (1)		interface	CDU
5.1.4 (3)	Figure 2.	Figure 2, Curve A for continuous operation and Curve B for intermittent operation.	
5.1.6	Add: 5.1.6 <u>Other Environmental Conditions</u>. 5.1.6.1 <u>Humidity</u>. IAW MIL-E-5400, paragraph 3.2.24.4. The equipment shall withstand the effects of humidities up to 100 percent, including condensation in and on the equipment during operating and nonoperating conditions. Fogging on the inside of the cover glass of instruments shall not occur. 5.1.6.2 <u>Shock</u>. IAW MIL-E-5400, paragraphs 3.2.24.6.1 and 3.2.24.6.3. No damage due to 18 shocks of 15 g, 11 ms along 3 axes, or due to bench handling/servicing. 5.1.6.3 <u>Sand and Dust</u>. IAW MIL-E-5400, paragraph 3.2.24.7. Operating and non-operating exposure to sand and dust particles. 5.1.6.4 <u>Fungus</u>. IAW MIL-E-5400, paragraph 3.2.24.8. 5.1.6.5 <u>Salt Atmosphere</u>. IAW MIL-E-5400, paragraph 3.2.24.9. 5.1.6.6 <u>Explosive Conditions</u>. IAW MIL-E-5400, paragraph 3.2.24.10. 5.1.6.7 <u>Rainfall</u>. The equipment shall withstand rainfall into the cockpit.		(After paragraph 5.1.5)
5.2.1 (5)		Regardless of existing USAF or commerical aircraft equipments, Appendix II reflects USAF commitment to NATO standard STANAG 3319. Appendix II will be annotated as to the preferred sizes, including lengths.	Appendix II

(continued)

Table D-1. (continued)

Paragraph Number	Delete Following Words	Add Following Words	After (or Remarks)
5.2.2 (3)		Further work is required on the dimensions listed in Figure 3.	Figure 3.
5.2.3 (3)	MS 25212. Many	MS 25212, including the maximum depth of 6.5". However, there is latitude for other than DZUS mounting per MS 25212. Many	to
5.2.3 (7)		or D	A or B
5.2.4	5.2.4 Other Mounting Areas. The needs of other mounting areas may be aircraft-unique.	5.2.4 Installation Area. The intent of this standard, is to cover all installation areas with the same requirements for similar equipments.	
5.2.5 (11)		The datum is the rear surface of the front panel.	instrument.
5.3.2 (29)		Type D-Direct air impingement when approved by the procuring activity.	5.3.7 (following the text on Type C cooling)
Figure 5	Panel Mounted		Figure 5 -
Figure 6	Panel Mounted		Figure 6 -
Figure 6	MS 25212 (DZUS) Mounted Unit		
5.3.5.1 (1) through (9)	The air flow rate should be ... ... in ground or flight operations.	design airflow rate shall be in accordance with the mass folow versus inlet bulk temperature relationships shown in Figure 9.	Flow-Through (Type A) Cooling
Figure 9, Page 14	Figure 9 illustration	Figure 14 illustration from MIL-STD-XXX	
5.3.7a (3)	85°C	95°C	-40°C to
5.3.7b (3)	70°C	71°C	-15°C to
5.3.7.1 (4)	-62°C to 95°C	-47°C to 95°C per MIL-E-5400T, Table I, Class 2	range of

(continued)

Table D-1. (continued)

Paragraph Number	Delete Following Words	Add Following Words	After (or Remarks)
5.3.8 (1) through (10)	Coolant Air Temperature (Types A and B). The bulk... ... 15.5°C to 40°C.	Coolant Air, Bulk Temperature at the LRU Inlet, Minimum to Maximum. Transient: -54°C to 71°C (10 minutes). Normal: -54°C to 40°C (continuous).	(Rewrite entire paragraph as per MIL-STD-XXX, paragraph 5.5.4.1)
5.3.9 (1, 2)	Coolant Air Relative Humidity. The coolant air shall contain no entrained condensate.	Coolant Air Quality. Under ECS fault conditions, the coolant air can contain up to 154 grains of water per pound of dry air. The coolant air shall not contain contaminant particles in excess of 400 microns.	(Rewrite paragraph as per MIL-STD-XXX, paragraph 5.5.4.5 and 5.5.4.6.)

APPENDIX E

STRAWMAN ADDENDUM TO MIL-STD-XXX:
AIR FORCE AVIONICS INSTALLATION STANDARDS FOR
HIGH-POWER-DISSIPATION LRUS

1.0 SCOPE

This addendum to the Air Force Avionics Installation Standard specifies the preferred mounting and cooling interface configuration for avionics LRUs that, for valid functional reasons must exceed the limits set forth in MIL-STD-XXX for standard avionics bay installations.

All of the sections and paragraphs of MIL-STD-XXX shall be applicable except as amended herein.

2.0 REFERENCED DOCUMENTS

This section is applicable in its entirety.

3.0 NOMENCLATURE AND DEFINITIONS

3.1 The Line Replaceable Unit (LRU)

Extended LRU dimensions are defined in paragraph 5.1.1 of this adendum.

3.2 Cooling Medium

High cooling capacity air supply, and liquid cooling system interfaces are defined in paragraph 5.2.3.2.

4.0 GENERAL REQUIREMENTS

4.1 Objectives

A further objective added by this addendum is:

(f) A definition of preferred interface configurations for high power dissipation LRUs.

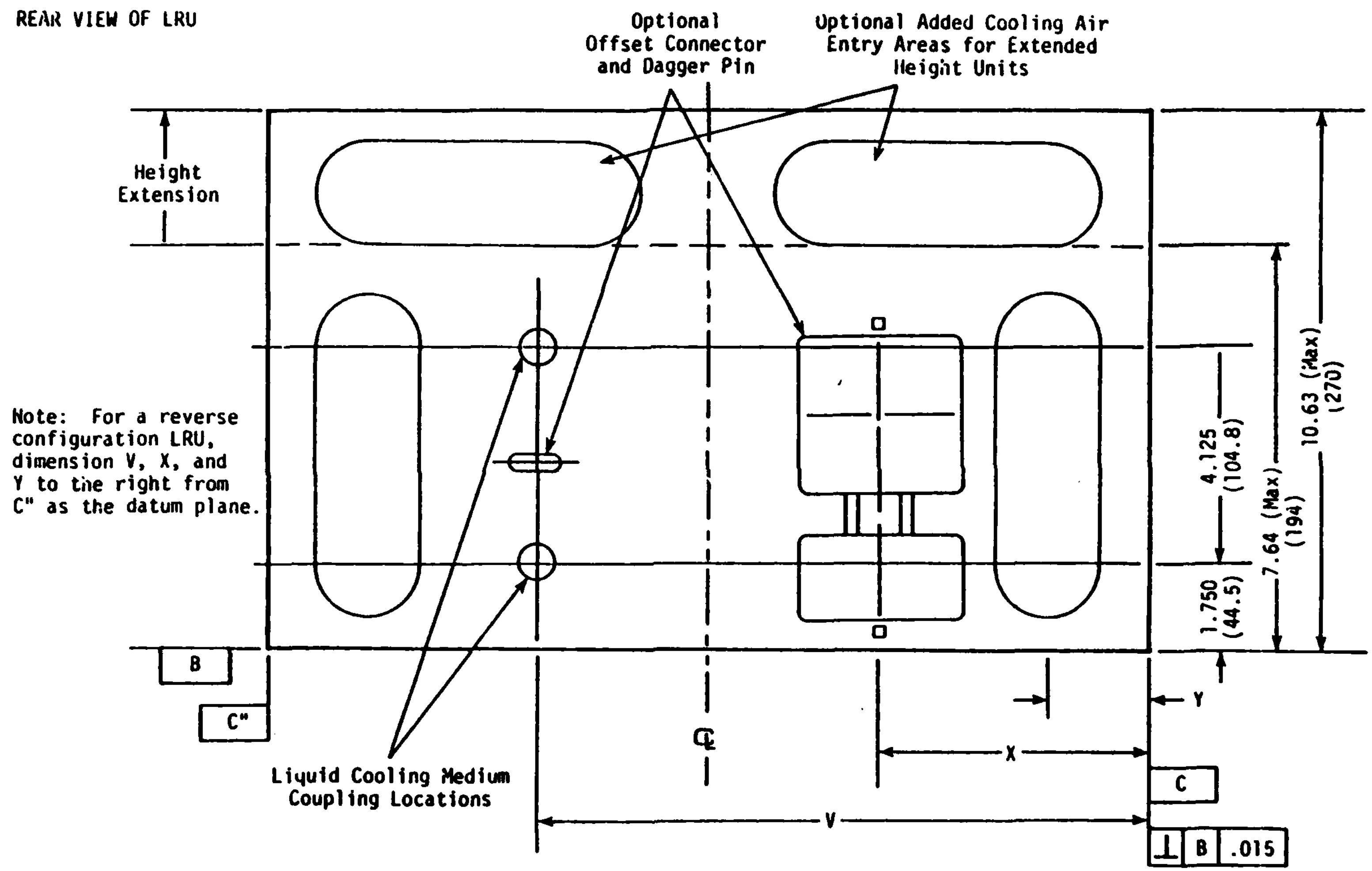


Figure A1-2. LRU REAR PANEL LOCATIONS AND DIMENSIONS FOR STANDARD HIGH-DISSIPATION AVIONICS LRUs

5.0 DETAILED REQUIREMENTS

5.1 The LRU

This paragraph is applicable.

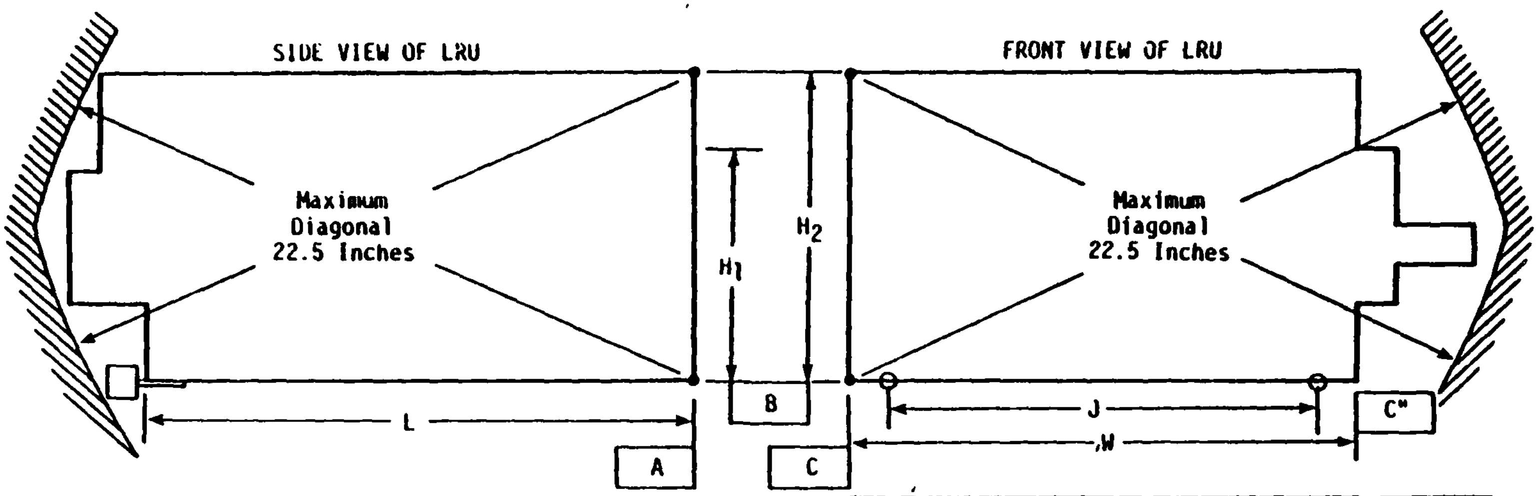
5.1.1 Form Factor and Case Dimensions - The high power dissipation LRU form factor is specified by its base dimensions (L and W), its backplate dimensions (W and H), and an overall envelope limit as illustrated in Figure A1-1. The preferred base dimensions correspond with those given in paragraph 5.1.1 of MIL-STD-XXX. Additional increments of length and width for use when necessary shall be in accordance with Tables I, II, and III herein.

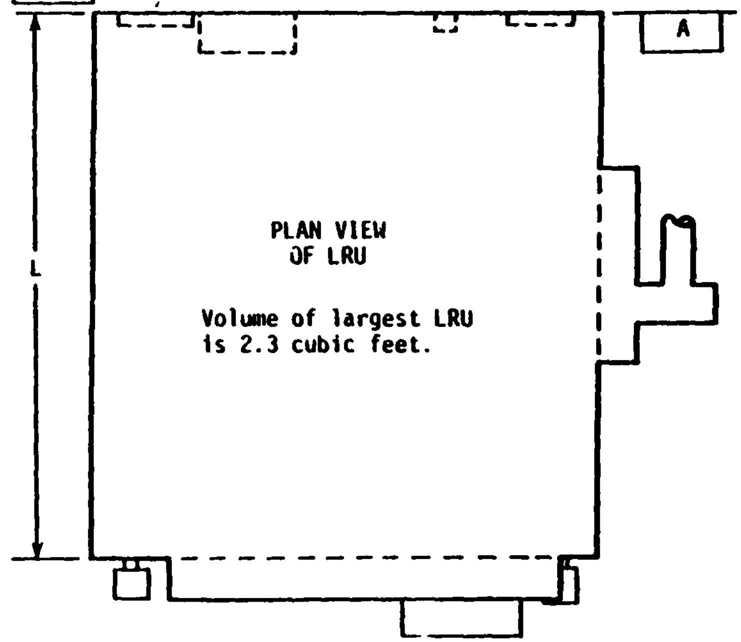
TABLE I - WIDTH OF LRU BASE INTERFACE (W)

LRU Size	Inches ± .020	MM ± 0.5
13	16.6	421.6
14	17.9	454.7
15	19.2	487.7

TABLE II - LENGTH OF LRU BASE INTERFACE (L)

Number	Inches ± 0.02	Millimeters ± 0.5
8	10.1	256.5
9	11.4	289.5
10	12.7	322.5
11	14.0	355.5
12	15.3	388.5
13	16.6	421.5
14	17.9	454.5
15	19.2	487.5





Dimension J		
LRU Size	In. ± 0.02	mm ± 0.5
13	14.3	363.3
14	15.6	396.3
15	16.9	429.3

Note: For a reverse configuration LRU, dimension the side envelope diagonals to the left from C" as the datum plane.

Figure A1-1. DATUM PLANES AND DIMENSIONS FOR STANDARD HIGH-DISSIPATION AVIONICS LRUs

TABLE III - HEIGHT OF BACKPLATE INTERFACE

	Inches Max.	MM Max.
Normal (H_1)	7.64	194
Extended (H_2)	10.63	270

5.1.1.1 <u>LRU Hold-downs</u>

The hold-down devices shall be appropriate to the weight of the LRU and the specified flight loads.

5.1.1.2 <u>Front Panel Protrusions</u> - No part of the LRU shall exceed the envelope shown in Figure A1-1 herein. Side protrusions are similarly limited.

5.1.1.3 <u>Rear Panel</u> - The preferred rear panel configuration corresponds with paragraph 5.1.1.3 of MIL-STD-XXX. Additional areas of cooling air apertures or alternate cooling medium connections may be provided in accordance with Figure A1-2 herein.

5.1.1.4 <u>Maximum Weight</u> - This paragraph is not applicable; each LRU weight shall be declared. Where the weight of an LRU exceeds the applicable human factors handling limitations of MIL-STD-1472, adequate lifting attachments shall be provided, ground handling procedures shall be developed, and any necessary ground handling equipment shall be specified.

5.1.2 <u>Cooling</u> - This paragraph is not applicable; cooling requirements shall be declared in the thermal appraisal report required by paragraph 5.5.

5.1.3 <u>Ambient Pressure</u> - This paragraph is applicable when the declared cooling air or other cooling medium requirements (paragraph 5.1.2) are met.

5.1.4 <u>Loss of Cooling</u> - Each LRU shall be protected by automatic power shut down whenever the cooling means becomes significantly degraded.

5.1.5 <u>Electromagnetic Compatibility</u> - The requirements of MIL-STD-461 Part 2. apply.

5.1.6 <u>Environmental Considerations</u> - This paragraph is applicable in its entirety.

5.2 The Equipment Rack

The mounting arrangements and cooling interfaces for high dissipation LRUs shall be independent of the aircraft's standard avionics LRU installation, unless their integration can be shown to impose no mutually adverse thermal, electro-magnetic or structural effects.

5.2.1 Datum and Method of Dimensioning - Dimensional control and the physical interchangeability of like LRUs is established by the use of datums (Figure A1-1) which are physical features from which other locations can be measured. Figure A1-2 and paragraph 5.2.3 show the method of dimensioning the mounting and cooling interface for high dissipation LRUs.

5.2.2 LRU Spacing on Rack Shelf - This paragraph is not applicable.

5.2.3 Mechanical Interface with the LRU - This paragraph and its subparagraphs are replaced by the following: Figure A1-3 defines the preferred attachment locations and hold-down methods designed to accomodate the most likely mounting situations.

5.2.3.1 Rear Hold-down - In all cases where a MIL-STD-XXX rack and panel connector is employed, it shall constitute the primary rear mechanical hold-down. A separate locator (dagger) pin that engages in an oval slot see Figure A1-2 shall be used where supplemental angular restraint and load sharing is needed.

5.2.3.2 Cooling System Interface - The preferred cooling interface is a butt jointed forced air connection sealed by a foam gasket. If liquid cooling is necessary, self sealing supply and return quick disconnect couplings shall be provided. For both air and liquid cooling reliable coupling, decoupling and sealing shall be performed automatically as the LRU is entered and secured in, or removed from, its mounting.

5.2.3.3 Front Retainer - TBD

5.2.3.4 Load Factor - Each individual rack mounting arrangement shall be stressed to meet the flight loads envelop applicable to the aircraft and mission, for the declared LRU weight.

5.2.4 Electrical Bonding Interface - This paragraph is applicable.

5.2.5 Environmental Considerations - This paragraph is applicable in its entirety.

5.2.6 Rack Maintenance and Accessibility - This paragraph is applicable.

5.2.7 Rack Design Evaluation - This paragraph is applicable.

5.3 The Rack and Panel Connector

The preferred connector is the MIL-STD---- for which paragraph 5.3 applies in its entirety, except that the connnector position shall be selected as shown in Figure A1-2. Any additional or alternate pendant cable connectors shall comply with MIL-C-38999.

5.4 Wire Integration

This paragraph is not applicable.

5.5 Thermal Management

The intent of this paragraph and subparagraphs is applicable; however because thermal management is a major factor in the design and qualification of each high dissipation avionics LRU/Subsystem and its method of installation, an individual thermal performance test specification shall be prepared for each case. This document shall include full details of the Cooling Evaluation Test required of the LRU/Subsystem, as installed.

5.6 Power Quality

This paragraph is applicable.

5.7 Mechanical and Structural Evaluation

This paragraph is applicable.

Appendix I Cooling Evaluation Test - This appendix is replaced by the individually tailored test procedures required to be conducted under paragraph 5.5 as modified herein.

ATTACHMENT

DRAFT AIR FORCE AVIONICS
INSTALLATION STANDARD
15 DECEMBER 1981

PROPOSED MIL-STD-XXX
15 DECEMBER 1981

NOTE: This draft, dated 15 December 1981 prepared by AFSC, ASD/AXA/XRS has not been approved and is subject to modification. DO NOT USE PRIOR TO APPROVAL

DRAFT AIR FORCE AVIONICS INSTALLATION STANDARD
(Superseding Strawman Standard dated June 1981)

CONTENTS

CONTENTS (continued)

FIGURES

CONTENTS (continued)

FIGURES (continued)

APPENDIXES

AIR FORCE AVIONICS INSTALLATION STANDARD

1. SCOPE

1.1 Scope. This Standard defines the form factor mounting, and cooling criteria to be used for military avionics equipment and the associated equipment rack, together with the specific dimensions and environmental characteristics of a set of standard avionics packaging modules which shall govern the exterior design of new and repackaged avionics equipment that is intended to be installed in the avionics bays of military aircraft. This Standard will not be applied to cockpit equipment, pod-mounted avionics, to missiles, or to intrinsically high dissipation components, or to units necessarily installed near the extremities of the airframe structure.

This Standard sets forth:

(a) The definition, guidance, and appraisal for design and acceptance of the electrical connector, mechanical and environmental interfaces between LRUs and the racks or trays in which they are installed.

(b) The definition, guidance, and appraisal for design and acceptance of the mechanical and environmental interfaces between racks or trays and the aircraft in which they are installed.

It is intended that this Standard shall be provided for use by using commands, avionics development agencies, airframe manufacturers, and avionics manufacturers. It is strongly desired that this Standard be used by all military organizations for aircraft avionic equipment installations, and that all system and subsystem developers are required to adhere to these requirements when specifying and developing new avionics systems.

2. REFERENCED DOCUMENTS

2.1 Documents. The following documents, of the exact issue listed, form a part of the specification to the extent specified herein. Copies of specifications, standards, handbooks, drawings, and publications required should be obtained from the procuring activity or as directed by the contracting officer.

2.2 Precedence of Documents. In the event of a conflict between the contract, this Standard, or the referenced documents, the following precedence shall apply:

(a) The contract and its attachments shall have precedence over any specification or reference document.

(b) This Standard shall have precedence over all referenced documents. Any deviation from, or exception to any portion of the Standard, shall be approved in writing by the contracting activity.

2.3 List of Documents

SPECIFICATIONS

Military

MIL-E-5400T	16 Nov 79	Electronic Equipment, Airborne, General Specification for
MIL-B-5087B Amend. 2	31 Aug 70	Bonding, Electrical, and Lighting Protection, for Aerospace Systems
MIL-E-6051D	5 Jul 68	Electromagnetic Compatibility Requirements, Systems
MIL-E-87145	21 Feb 80	Environmental Control, Airborne

Commercial

10-61953 Rev G The Boeing Co.	14 Nov 80	Specification Control Drawing for Connector, Electric, Low Insertion Force, Rectangular

STANDARDS

Military

MIL-STD-210B	15 Dec 73	Climatic Extremes for Military Aircraft
MIL-STD-461B	1 Apr 80	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference
MIL-STD-704C	30 Dec 77	Aircraft Electric Power Characteristics
MIL-STD-810C	10 Mar 75	Environmental Test Methods
MIL-STD-1472B	31 Dec 74	Human Engineering Design Criteria for Military Systems, Equipment and Facilities
MIL-HDBK-217C	9 Apr 79	Reliability Prediction of Electronic Equipment

Commercial

NAS 622 Rev 1	31 Oct 61	Hook, Support, Electronic Equipment Clamp

3. NOMENCLATURE AND DEFINITIONS

3.1 The Line Replaceable Unit (LRU). The basic Line Replaceable Units (LRUs) around which the entire packaging and installation concept is constructed are of uniform length and height. The width shall be selected (or specified) from a range of modular sizes numbered 2 through 12. Any combination of LRUs installed side by side occupy shelf space equal to the sum of their size numbers multiplied by 33 millimeters (1.3 inches). The individual LRU widths are given in Table I.

TABLE I - LRU DIMENSIONS

LRU Size	Width - W: Inches ± 0.020	Width - W: Millimeters ± 0.5
12	15.29	388.4
11	13.99	355.3
10	12.69	322.3
9	11.39	289.3
8	10.09	256.3
7	8.79	223.3
6	7.50	190.5
5	6.19	157.2
4	4.88	124.0
3	3.56	90.4
2	2.25	57.2

Lengths L_1 = 318 ± 1.0 mm (12.51 ± .04 in.)

L_2 = 324 mm max. (REF) in. (12.76 in.), See Figure 1

Height H = 194 $^{+0.0}_{-1.0}$ mm (7.64 $\pm ^{.00}_{-.04}$ in.)

When a deviation above the standard length is unavoidable, the value of 502 mm (19.74 in.) shall be used.

The correlation between the LRU sizes and Air Transport Racking (ATR) box sizes is as follows:

- The height is the maximum allowed for ATR
- The length is approximately equivalent to ATR short
- The width equivalencies are:

Size 12	1 1/2 ATR
Size 8	1 ATR
Size 6	3/4 ATR
Size 4	1/2 ATR
Size 3	3/8 ATR
Size 2	1/4 ATR

3.2 The Equipment Rack and Shelf. The designation "equipment rack" pertains to the structure on which a number of LRUs are installed. The equipment rack shall be designed so best use can be made of the available space, often resulting in more than one tier of equipment. The structure upon which any one tier of equipment is mounted is designated a shelf. Shelves provide the support points which mechanically locate the LRU. The rack electrically interfaces the LRU with the aircraft wiring and other LRUs, and interfaces the LRU with the equipment cooling system. An equipment rack may be open or partially enclosed, or it may be entirely enclosed to meet specific requirements.

3.3 LRU Guides and Holddowns. LRU guides and holddowns on the shelf, or coordinated into the design of a mounting base or tray, provide dimensional control between the LRU, the rack connector, and the cooling air interface.

3.4 The Electrical Interface. The electrical interface between the LRU and the aircraft wiring is provided by a low insertion force rack and panel connector. The metal or structural component on which the rack half of the connector is mounted to the rack is designated as the backplate.

COMMENTARY: The words "low insertion force" (LIF) will be used throughout to describe the connector. The limits of these forces are discussed in 5.3.2.4.

3.5 Electrical Power Supply. The characteristics of the electrical power supplied to the equipment racks are usually described/controlled by the airframe manufacturer's specification for the particular aircraft. MIL-STD-704 describes the limits of deviation of the power quality from nominal under steady-state, normal, abnormal, and emergency conditions of operation in the aircraft electrical system.

3.6 Cooling Air Ducts and Plenums. Ducting and plenums are members built into or mounted on the rack or adjacent structures to direct the flow of cooling air to the LRU. Mating apertures in the LRU provide for passage of the cooling air through the unit.

3.7 Electronic Part. An electronic part, for the purpose of this document, is defined as an item not subject to further disassembly which is utilized in the fabrication of avionic equipment. For example: resistors, capacitors, filters, circuit breakers, switches, connectors (electrical), relays, coils, transformers, piezoelectric crystals, electron tubes, transistors, diodes, microcircuits, waveguides, synchros, and resolvers.

3.8 Temperature-Critical Parts. Temperature-critical parts are electronic parts whose operating temperatures are most likely to approach their maximum allowable temperature.

3.9 Thermal Stabilization. A stabilized thermal condition has been attained when the indicated temperature of all temperature sensors internal to the test chamber (including the instrumented test unit electronic parts) have varied no more than 2°C over a continuous one-hour exposure period.

3.10 Maximum Steady-State Heat Dissipation. Maximum steady-state heat dissipation is the condition wherein the equipment is operated at the maximum steady-state supply voltage level through the normal operational duty cycle which will yield the maximum heat dissipation.

3.11 Ambient Temperature. Ambient temperature is the air temperature immediately surrounding the equipment rack.

3.12 Thermal Design Conditions. The thermal design conditions are the environmental and electrical operating modes to be used as the basic design conditions for the equipment.

3.13 Sea Level Pressure. Standard sea level ambient pressure for purposes of specification, test, and evaluation is 103.1 kilopascals (14.7 psi) absolute.

4. GENERAL REQUIREMENTS

4.1 Objectives. Application of this Standard will provide:

(a) A system of modularized avionics boxes.

(b) A system of modularized installation in racks or mounting bases.

(c) A standard means to guard against LRUs being inadvertently placed in the wrong rack location.

(d) A family of low insertion force electrical connectors to provide the electrical interface between the equipment and the aircraft wiring.

(e) A system for effective environmental control of the equipment.

5. DETAILED REQUIREMENTS

5.1 The LRU. This Standard specifies the interfaces between the LRUs and the electrical wiring, environmental control systems, and supporting structures. The internal configuration of the LRUs is the responsibility of the equipment developing agency. However, the specific limits of interfaces which are required for physical interchangeability, discussed in the following sections, shall be observed in each LRU design.

5.1.1 Form Factor and Case Dimensions. The LRU is a right parallelpiped. The height and length dimensions are fixed. Variations in LRU sizes are accounted for by modular increments in case width. The smallest LRU is designated "Size 2," and others are designated "Size n" where n is the number of modular units that would occupy the same shelf width as the case in question. The dimensions associated with each case size are shown in Figure 1 and Table I.

NOTE: The case sizes are derived from the short ATR boxes which have been the industry standard for black box design.

5.1.1.1 LRU Holddowns. The LRU shall have NAS 622 Type T holddown hooks installed as shown on Figure 2 or structurally equivalent projections from the box lip. For LRUs sizes 2, 3, 4, and 5 provisions shall be made for the optional attachment of NAS 622 Type T holddown hooks on the lefthand 194 mm (7.625 inch) edge of the front panel.

The LRU shall be capable of withstanding:

(a) The compressive forces exerted between the holddown hooks on the front of the box and the connector on the rear of the box.

(b) The vertical forces resulting from the downward component of the holddown devices, installed as shown on Figure 2, in addition to the specified flight loads (see 5.2.5.2).

(c) The tensile forces resulting from pulling the LRU out of its mating connector. The maximum values of the compressive and tensile forces shall be as follows:

LRU Size	2	3-12
Maximum axial force to be applied by holddown or other insertion device	560 Newtons (125 lb)	1120 Newtons (250 lb) (Equally divided between two hooks.)

5.1.1.2 Front Panel Protrusions. All protrusions such as carrying handles, switches, knobs, test connectors, and indicators shall lie within the outline envelope shown shaded in Figure 1.

5.1.1.3 Rear Panel. The primary purpose of the back of the LRU is for connecting to the cooling air supply and mounting the electrical connector. Any other use shall not interfere with the interfacing of the LRU with the rack. Connector-mounting screw heads shall lie within the limits shown in Figure 1.

The connector position on an LRU shall be as specified in Figure 3. The rear mounting surface shall have a maximum thickness of 2.5 mm in the connector mounting area, ZONE 'A'.

COMMENTARY: Projections on the LRU backplate surface are permitted provided there is no interference with the rack backplate, as provided by the dimensioning and tolerancing specified in Figures 1 and 13G.

5.1.1.4 Maximum Weight. Maximum weight limits shown in Table II are assigned to enable adequate structural design of racks and shelves which must carry the loads. In no case shall a unit having a weight of more than the amount given in Table II be installed. A lower maximum weight is imposed upon the larger LRUs for handling purposes by the requirements of MIL-STD-1472. These constraints shall apply to the extent specified by the design specification of each individual LRU. Each LRU not in compliance with MIL-STD-1472 single-person lift/carry limitations shall bear a permanent warning label on the front of the box showing its weight.

TABLE II - LRU MAXIMUM WEIGHT

LRU Case Size Number	Maximum Permissible Weight	
	Pounds	Kilograms
2	14.3	6.5
3	22.0	10.0
4	29.7	13.5
5	37.4	17.0
6	45.1	20.5
7	52.8	24.0
8	60.5	27.5
9	68.2	31.0
10	75.9	34.5
11	83.6	38.0
12	90.2	41.0

5.1.2 Cooling. When the LRU heat dissipation exceeds the values allowed for free convection and radiation cooling given in Table III, Column 3 "Without Cooling Air" the active cooling medium shall be forced air (as described in 5.5.4) moving through passages in the LRU. In all cases, the LRU designer shall make efficient use of the cooling air supplied to the unit. To this end, internal air distribution systems, baffles, heat exchangers, cold plates, heat pipes, etc., shall be judiciously employed to avoid hot spots. Cooling by air impinging directly on electronic components is not permitted. Particular attention shall be directed to avoiding air leaks that allow coolant to bypass heat transfer surfaces. Units which do not require forced air cooling shall not have openings on any surface other than small drain holes appropriately positioned. The maximum permissible power dissipation for equipment with cooling is defined in Table III, Column 2.

TABLE III - MAXIMUM LRU THERMAL DISSIPATION

LRU Case Size	Maximum Permissible Power Dissipation (Watts)		
	With Cooling Air	Without Cooling Air*	Without Cooling Air**
2	125	10	30
3	187	12	32
4	250	15	37
5	312	17	42
6	375	20	46
7	437	22	50
8	500	25	55
9	562	27	60
10	625	30	65
11	687	32	70
12	750	35	75

*Equipment mounted in avionics racking in accordance with this standard, but not requiring forced air cooling.

**Equipment mounted independently, with free circulation of ambient air not exceeding 55°C, not in proximity to heat radiating surfaces in excess of 55°C, and operating below 30,000 feet pressure altitude.

COMMENTARY: Only if units can pass the thermal appraisal tests set forth in 5.5.6 with no air at all may the manufacturer state that his LRU requires no forced cooling air. The use of the term "convection-cooled" is discouraged. Units not requiring forced air cooling shall pass appraisal test with no air provided to the unit.

5.1.2.1 Cooling Air Interface. The interface with the equipment cooling system shall be designed to minimize leakage. The interface with the cooling system is via apertures in the LRU in accordance with the details shown in Figure 3. The quantity and condition of cooling air flow through the unit is described in 5.5.4. The static pressure drop ($\sigma \Delta P_s$) through the LRU shall be 50.5 $\pm$ .5 mm (2 + .02 in) water gauge at the design flow rate for inlet conditions of 15.5°C. NOTE: σ equals 1 at 15.5°C and standard sea level pressure. The methods used to manage heat flow within the unit and to prevent temperature buildup at the power dissipating elements are not controlled by this standard. However, the results of that design shall be proven in the evaluation tests outlined in Section 5.5. See Section 5.5.4.3 on cooling pressure drop.

5.1.2.2 Power Dissipation. The power dissipated within the LRU shall be limited to the values shown in Table III.

COMMENTARY: For heat dissipation levels greater than those specified in Table III, refer to the "High Dissipation LRU Addendum."

5.1.2.3 LRU Cooling Evaluation. Each LRU design shall be proved by appraisal tests per Appendix I to demonstrate the unit's capability to perform and survive under the conditions set forth in this standard.

5.1.2.4 Drain Holes. Each LRU shall have drain holes to prevent condensed moisture accumulating in the electronic assembly compartment(s).

5.1.3 Ambient Pressure. When supplied with cooling air at the rates specified in 5.5.4.2, each LRU shall provide specified performance at altitudes up to 70,000 feet. Non-operating exposures to ambient air at altitudes up to 70,000 feet shall not cause damage to the LRU.

5.1.4 Loss of Cooling Air Supply. Under any operating condition specified herein, loss of or reduction in the flow rates of cooling air shall not cause degradation of LRU performance below specified limits, or damage to the LRU:

(a) Loss of Cooling Air Supply: LRU shall perform and survive 10 minutes of operation

(b) Emergency Ram Air Cooling: LRU shall perform and survive 30 minutes of operation.

5.1.5 Electromagnetic Compatibility. Although the rack is required (see 5.2.5.4) to protect LRUs mounted within it from radiated and conducted noise originating external to the rack, it cannot protect its LRUs from each other, or from outside interference conducted in on RF signal lines. Consequently, LRUs shall be designed to comply with the requirements of MIL-STD-461, Part 2, Class A1b.

5.1.6 Service Conditions (Environmental). Each LRU shall be capable of operating with no degradation in performance under each of the service conditions specified in MIL-E-5400, paragraph 3.2.24; subparagraphs 3.2.24.1 through 3.2.24.10 subject to the following classifications, as defined by MIL-E-5400, paragraph 1.2:

(a) Without forced air cooling -- Class 2

(b) With forced air cooling -- Class 2X

and to the specification levels given in the following subparagraphs.

5.1.6.1 Temperatures

(a) Non-Operating Survival Temperatures and Temperature Shock, -62°C to 95°C at rates up to ±1°C per second. NOTE: These are the lowest and highest ground temperatures expected to be experienced by equipment during aircraft storage, or exposure to climatic extremes with power off. Equipment is not expected to be capable of operating at these temperatures, but to survive them without damage.

(b) Short Term Operating Temperature, 30 Minutes Duration -40°C to 95°C.

(c) Low and High Operating Temperature, Ground or Flight, Continuous, -15°C to 71°C.

(d) Temperature Shock, temperature changes between -62°C and 95°C at rates up to ±1°C per second.

5.1.6.2 Altitude

Operating and non-operating, sea level to 70,000 feet at rates of change up to 13 millimeters of mercury per second.

5.1.6.3 Temperature Altitude Combination - as shown in Figure 4

(a) Continuous operation - Curve A

(b) Intermittent operation - Curve B

5.1.6.4 Vibration

Hard mounted, LRU random vibration levels are specified in Figure 5.

(a) Endurance without damage

(b) Performance without degradation

5.1.6.5 Acceleration

(a) Steady acceleration levels for operation with no performance degradation, misalignment, or damage are:

Horizontal plane -- 6.1g
Vertical axis -- up 10.4g; down 4.1g

Where the orientation of an LRU in the aircraft is not determined by its functional characteristics, the steady acceleration for all axes shall be 10.4g.

(b) Steady acceleration levels for positive retention in the mounting (damage allowed) are 1.5 times the values of 5.1.6.5.(a).

COMMENTARY: Any unnecessary constraint of the mounting orientation of an LRU will reduce its general applicability, and interchangeability between aircraft types and models.

5.1.6.6 Other Environmental Conditions

(a) Humidity - operating and non-operating - 100% with condensation on and in the LRU.

(b) Shock - in accordance with MIL-E-5400, paragraph 3.2.24.6.3

(c) Explosive decompression

(d) Sand and Dust - in accordance with MIL-E-5400, paragraph 3.2.24.7

(e) Fungus - in accordance with MIL-E-5400, paragraph 3.2.24.8

(f) Salt Atmosphere - in accordance with MIL-E-5400, paragraph 3.2.24.9

(g) Explosive Atmosphere - in accordance with MIL-E-5400, paragraph 3.2.24.10

(h) Ozone?

5.2 The Equipment Rack. An equipment rack provides a method of installing a number of LRUs in any particular location in the aircraft. Individual shelves and trays are used to provide a mounting platform for the equipment. The equipment rack provides a means of interfacing the LRU with aircraft wiring, equipment cooling system, and other equipment in the aircraft.

Rack structure will vary depending on aircraft constraints such as available space, equipment required, and mechanical considerations. The rack may be of open construction, or it may be partially or entirely enclosed to meet specific environmental or EMI requirements.

The overall form factor of the rack is optional, to allow each airframe manufacturer to best accommodate the required LRUs within the volume available. The general arrangement of a typical rack assembly is shown in Figure 6.

5.2.1 Datum and Method of Dimensioning. Dimensional control is established by use of datums which are physical features from which other locations can be measured. (Datums are as shown in Figures 1, 2, 3, 7, 8, 9, 10, 12, and 13.)

5.2.2 LRU Spacing on Rack Shelf. Shelves shall be designed to accommodate any combination of LRU trays or guides. Figure 6 shows a typical shelf arrangement.

The spacing between LRU guides on a shelf is given in Figure 8. These guides direct and position the LRU so that the connector on the rack or backplate and the connector on the LRU will align for mating.

The spacing between the guide surface of one LRU guide and the adjacent guide surface on the next LRU guide and the application of these dimensions to a shelf is shown on Figure 7. The use of the term "LRU guides" as defined in this specification (ref. para. 3.3, as opposed to the term "tray") is not to imply trays cannot be used as LRU guides but is to emphasize the option of the airframe manufacturer to select either trays or rails as LRU guides. Interguide spacing and LRU tray widths are equal.

For all LRU sizes and combinations of LRUs the total assembled width of any other group of LRUs (including spacing) is equal to the width of any other group of LRUs (including spacing) having the same arithmetic sum of modular sizes.

5.2.3 Mechanical Interface with the LRU. The rack shall be designed such that individual LRUs can be installed in or removed from the rack without disturbing any other LRU. The rack shall provide the mechanical attachment points required by each LRU, i.e., the electrical connector shell at the backplate, and the attachment points for holddowns. The location of holddown attachments shall be as shown in Figure 8.

5.2.3.1 Back Plate Assembly. The assembly of the backplate to the shelf, tray, or rack structure, shall be designed to meet the tolerance requirements shown in Figure 9.

The backplate deflection during the period when the LRU is installed, is being installed, or is being removed from the rack shall not exceed the dimensions specified in Figure 9 (see 5.3.2.4 for allowable LRU insertion forces).

COMMENTARY: One of the objectives of this specification is to overcome the problem of deflection forces applied to the rack due to high density electrical connectors --thus the use of low insertion force connectors (see Section 5.3). It should be recognized, however, that even with low insertion force connectors, it is still necessary to apply some force to engage the connector. The rack trays and backplates shall be designed to be compatible with these forces. Gauging of the shelf backplate is considered essential to establish the perpendicularity of the shelf connector mounting face relative to the plane of the shelf load-bearing surface.

5.2.3.2 Cooling System Interface. The rack will serve as the interface between the electrical/electronic equipment cooling system and the LRU. The racking shall include ducting so arranged that the cooling medium can be delivered to the LRU through the openings shown in Figures 9 and 10.

Metering plates shall be used to control the air flow as required by each LRU. (See 5.5.4.2.) The coolant air static pressure drop through the rack shall be TBD ± 0.5 mm water gauge at the rated flow rate, at $15.5^{\circ}C$ and standard sea level pressure.

Prevention of loss of cooling air when an LRU is temporarily removed from the aircraft shall be controlled by the tray or rack.

5.2.3.3 Front Retainer. The shelf, rack, or tray shall provide a force-limiting, manually-operated means of pushing the LRU into its mating connector, means of holding the LRU in place, and a means for extracting the LRU from its connector. A protective barrier or top shelf shall be provided to prevent the front of an unlatched LRU being raised more than 5 millimeters when being inserted in or extracted from the rack.

5.2.3.3.1 LRU Holddown Details. The means for inserting and holding down the LRU to the shelf are as shown on Figure 8. The line of application of the insertion force shall be inclined to the horizontal as shown. The resultant horizontal component of the force applied by each holddown shall be limited to 560 Newtons (125 lb) by a mechanism which prevents over stressing the LRU. The interface of the LRU with the shelf/rack holddown is the NAS 622 T hook. Forces on Sizes 3 through 12 LRUs are to be provided by two holddown devices as shown on Figure 8.

Additional requirements of the LRU holddowns are as follows:

(a) The front of the LRU must be securely held to the shelf.

(b) The LRU connector must be retained in the fully mated position with the rack-mounted connector.

(c) The attachment must absorb tolerances of the shelf, and of the LRU length as given in Table I.

(d) Release and removal of an LRU with a failed holddown shall be readily accomplished.

(e) The holddown force is limited by means supplied with the rack or tray. The values of force exceed the contact insertion force by allowances for misalignment of the LRU with the rack during initial engagement, location of the box on the shelf, and securing of the holddown devices.

5.2.3.3.2 LRU Extractor Details. The shelf, rack, or tray shall provide an extractor mechanism which gives mechanical advantage to assist in removing the LRU from the rack. The extractor may operate against the front lip as shown on Figures 1 and 8. The extractor shall conveniently apply forces as follows:

LRU Size	Size 2	Sizes 3 to 12
Minimum Extractor Force	560 Newtons (125 lb)	1120 Newtons (250 lb)

5.2.3.3.3 Low Profile Mounting Tray. Where necessary, a size 2, 3, 4, or 5 LRU can be mounted on its side in a specially adapted tray such as that illustrated in Figure 9, unless a specific mounting attitude is required for functional reasons.

5.2.4 Electrical Bonding Interface. All metal parts of the rack and shelves shall be maintained at airframe potential by the application of suitable bonding and grounding techniques. The ground path provided shall be capable of conducting the maximum fault (short circuit) current to which the rack may be exposed. Under such conditions, the resistance of the ground path shall not exceed 2.5 milliohm in accordance with MIL-B-5087, para. 3.3.5.1. The ground path shall provide the greatest surface area possible to allow a low impedance ground path for radio frequency currents.

5.2.5 Service Conditions (Environmental). The rack or tray assembly shall withstand the service conditions specified in MIL-E-5400, paragraph 3.2.24; subparagraphs 3.2.24.1 through 3.2.24.10, and the avionics LRUs shall remain within the alignment tolerances of Figures 8 and 9 and shall not suffer damage or fail to operate due to environmental conditions applied to the rack or tray assembly as follows:

5.2.5.1 Vibration Environment. The avionics installation concepts and design approaches employed shall address the location of the standard avionics, and the design of the racks, shelves, and trays, to control the vibration inputs that are transmitted to the avionics equipment to no more than 0.04 g^2/Hz between frequency limits shown in Figure 10.

> COMMENTARY: While most locations in the avionics bays of fighter aircraft can meet this requirement without any special design considerations, some locations may be affected by more severe vibrations such as gunfire. The aircraft environment will be controlled to these levels whenever possible. This will facilitate the wide use of standard avionics equipment, without imposing worst case environmental requirements on all Air Force avionics, which would not be cost effective. It is recognized that in some instances this is not practical and avionics developed to this standard will not be applicable.

5.2.5.2 Acceleration. LRUs shall be supported to withstand the steady accelerations of 5.1.6.5.(a) without damage to supporting structures and while maintaining alignment tolerances. LRUs and supporting structures will remain intact and restrained when exposed to the steady accelerations of 5.1.6.5.(b).

5.2.5.3 Temperature/Altitude. The rack or tray shall be designed to operate in the temperature/altitude environment shown in Figure 4 and temperature shock rates of change up to $\pm 5^{\circ}$ per second over the range -62°C to 95°C.

5.2.5.4 Electromagnetic Interference. The rack, tray, and connector design shall incorporate means to exclude radiated or conducted EMI originating outside the rack. The avionics and rack assembly, as installed in the aircraft, shall meet the requirements of MIL-E-6051.

5.2.5.5 Other Environmental Conditions

(a) Humidity - operating and non-operating - 100% with condensation on and in the LRU

(b) Shock - in accordance with MIL-E-5400, paragraph 3.2.24.6.3

(c) Explosive Decompression

(d) Sand and Dust - in accordance with MIL-E-5400, paragraph 3.2.24.7

(e) Fungus - in accordance with MIL-E-5400, paragraph 3.2.24.8

(f) Salt Atmosphere - in accordance with MIL-E-5400, paragraph 3.2.24.9

(g) Explosive Atmosphere - in accordance with MIL-E-5400, paragraph 3.2.24.10

(h) Ozone?

5.2.6 Rack Maintenance and Accessibility. Easy access is required to allow maintenance and modification work on wiring, wire integration, connectors, mechanical devices, environmental control facilities, etc. The rack shall be so designed that normal hand tools may be used in maintenance, and space for the use of those tools shall be adequate.

5.2.7 Equipment Rack Design Evaluation. The rack shall be evaluated in accordance with the thermal management mechanical and structural considerations procedures defined in 5.5 and 5.7 to ensure that it meets the design criteria established above.

5.3 The Rack and Panel Connector. The rack and panel connector used for equipment designed to meet this specification shall utilize low insertion force technology. The connector shall provide the electrical and rear mechanical interface between the LRUs and the aircraft equipment rack.

The rack and panel connector shall meet the requirements of Boeing Drawing Number 10-61953, "Connector, Electric, Low Insertion Force, Rectangular".

COMMENTARY: Until such time as an industry standard for the connector can be established, (e.g., MIL-SPEC, SAE Standard) the Boeing drawing will be used as the definition of the requirements for the connector. However, for those who do not have immediate access to the Boeing drawing, the following are some of the general characteristics of the connector.

5.3.1 Connector Electrical Considerations

5.3.1.1 The rack and panel connector shall accommodate combinations of the following contacts:

(a) Low insertion force size 22 "signal" contacts with a 5 ampere, 115 volt RMS continuous duty rating.

(b) Conventional power contacts to include sizes 12, 16 and 20.

(c) Conventional coaxial contacts.

(d) Waveguide

COMMENTARY: Fiber optic and pneumatic connections to LRU will be required in the immediate future.

5.3.1.2 The connectors shall accommodate interfacing of electrical circuits ranging from 0 amps (dry circuits) to 50 amps. The signal section shall carry currents up to 5 amps maximum on any one pin. Currents higher than 5 amps shall be carried by conventional round pins and sockets in the power insert.

5.3.1.3 A family of rack and panel connectors is shown in Boeing Drawing Number 10-61953. The rows of contacts shall be numbered in accordance with Figure 11.

5.3.1.4 The shell of the connector shall include provisions for physical barriers between inserts required to satisfy circuit separation requirements. Contacts shall not protrude beyond the connector shell.

5.3.1.5 Connector inserts shall be individually replaceable in the field.

5.3.1.6 Connectors shall be intermateable between manufacturers.

COMMENTARY: This does not imply that inserts of different manufacturers shall be interchangeable.

5.3.1.7 The contact-to-wire interface designs shall be compatible with the use of either stranded or solid conductor wire including flat conductor cable. The electrical contacts shall be available with crimp barrels, and round and rectangular posts.

Wire termination contacts are to be intermateable, interchangeable, and replaceable between manufacturers.

Crimp contacts shall be all rear release and rear removable. Contacts shall be positively retained by the insert.

The connector contacts shall not be used as a switch to apply and remove power to LRUs.

COMMENTARY: This means that some procedural method shall be used to ensure that power is removed before the LRU is installed in or removed from the rack, e.g., the circuit breaker shall be opened.

5.3.2 Connector Mechanical Considerations. The connector shell will serve as the mechanical interface between the rear of the LRU and the equipment rack. The mated shells of the connector shall be of sufficient strength to retain the LRU in position in all three axes when subjected to axial, vertical, and side loads of para. 5.2.3.4. and the shock loads specified in MIL-E-5400, paragraph 3.2.24.6.1 and paragraph 3.2.24.6.2 This requires that the holddowns used to restrain the front of the box are properly secured and are also capable of meeting this three-axis requirement. The force required to keep the connector halves mated shall be provided by the front mounted retainers (holddowns). The connector shell shall be designed to accommodate a LRU/shelf lateral misalignment of 2.5 mm (0.1 in.).

COMMENTARY: In retrofit applications, when it is not cost effective to modify the aircraft's existing racking and wiring installation, so that a rear-mounted rack and panel connector cannot be used, the rear holddown shall be provided by a wedge projection from the base of the LRU in accordance with Figure 12. Under no circumstances shall this wedge or any other alternate rear holddown co-exist with the standard rear connector specified herein.

5.3.2.1 Engagement of the connector contacts shall be automatically achieved through the action of inserting the LRU in the rack.

5.3.2.2 The connector shell shall act as a stop or limit for LRU insertion into the rack. The shells shall be designed to withstand an axial compressive force of 1,000 lbs.

5.3.2.3 The connector and its engaging sequence are shown in Figures 13A through 13F.

5.3.2.4 The force to fully engage and disengage the mated pair shells and contacts shall not exceed 27 lbs for size 1, 60 lbs for size 2, and 105 lbs for size 3.

5.3.2.5 The signal contact center-to-center spacing is 0.100 inches on a 0.025-inch square grid pattern. All other contacts shall also be located on this same 0.025-inch square grid pattern.

5.3.2.6 The rack and panel connector shell shall provide for indexing capability to ensure that the LRUs are not inadvertently placed in wrong locations. The indexing shall be accomplished by means of three index pins located within the connector shell.

5.3.2.7 Indexing of connectors shall be numbered using the three index pins in the sequence LEFT; CENTER; RIGHT, each pin having the six possible positions shown in Figure 11. Each index position shall be accomplished without disturbing the electrical contacts of the contact portion.

5.3.3 Connector Environmental Considerations. Rack and panel connectors shall last the life of the aircraft (typically 100,000 hours operating time).

The rack and panel connectors shall provide environmental protection, and shall prevent moisture or other liquid contaminant from ingressing to the contacts either via the wire or at the connector-to-connector interface. Potential liquid contaminants are: water condensation and rain, salt spray, fuel, hydraulic fluid, de-icing fluid, coolants, lubricants. Further, the connector shall be designed to prevent the ingress of sand, dust, or other contamination into the connector when mated.

5.3.4 Connector Tooling and Maintenance Considerations. All techniques and processes used to connect electrical wires to the contacts and the means of inserting contacts in the insert, shall be compatible with automatic and semiautomatic installation techniques, but must also be capable of being accomplished by a flight line technician using inexpensive hand tools.

COMMENTARY: While automated wire termination processes may become economically justifiable for the airframe and equipment manufacturers, they may not be justifiable for maintenance operations. Therefore, any process which uses automatic or semi-automatic tools in the factory shall be backed up by inexpensive and easily operated hand tools and processes.

All contacts and connector components shall be marked permanently to identify the manufacturer.

5.3.5 Connector Installation Considerations

5.3.5.1 The LRU Electrical Interface. The connector will serve as the electrical interface between the rear of the LRU and the equipment rack. To ensure connector mateability the use of more than one connector is not permitted.

The connector shell is installed on the inside surface (Datum A, Figure 1) of the back, and projects into but not through the opening in the rear of the LRU. Connector mounting hardware shall be within the limits shown in Figure 13G to avoid possible interference with the mating rack connector support (see Paragraph 5.3.5.2).

COMMENTARY: In retrofit applications, when it is not cost effective to modify the aircraft's existing racking and wiring installation, so that a rear-mounted rack and panel connector cannot be used, the rear holddown shall be provided by a wedge projection from the base of the LRU in accordance with Figure 12. Under no circumstances shall this wedge or any other alternate rear holddown co-exist with the standard rear connector specified herein.

Where applicable, exposed sockets shall be located on the LRU receptacle while the more protected pins shall be located on the rack mounted plug. The number of electrical circuits allocated to the LRU connector shall take into account both test requirements and the operational function. Test requirements to be considered include airborne, on-board, and shop. Where a dedicated connector is required for on-board and/or shop testing it shall be located on the front of the LRU.

5.3.5.1.1 Connector Position. The connector position is as shown in Figure 3.

Close tolerance guides designed into the connector shell are used to accurately position the connector on the LRU backplate (see Figure 3). The locator bosses on the plane of the connector control the horizontal position and location feet control its vertical position, with reference to Datum C' and Datum B shown on Figures 1 and 3.

The use of locator bosses permits replacement of a damaged connector in the field with the same accuracy as achieved in the original factory installation and is not dependent on accurately located connector mounting holes.

5.3.5.1.2 Bonding and Grounding. The impedance from any point of the LRU chassis to the connector shell, when measured at a direct current equivalent to the maximum supply current of the LRU, shall not exceed 2.5 milliohms.

A primary ground is defined as a ground providing the low impedance path necessary to meet this requirement.

All electrical circuits inclusive of secondary ground connections will be via connected contacts.

AC and DC supply input grounds shall be routed through separate dedicated pins in the LRU connector.

COMMENTARY: A secondary ground connection is defined as a circuit wire only required to maintain a current path in unlikely failure of the main primary ground.

5.3.5.2 The Rack/Tray Electrical Interface. The electrical interface between the rack/tray and the LRU shall be accomplished through a low insertion force connector mounted on the backplate of the shelf or LRU tray.

The connector shell is installed on the front surface (Datum E, Figure 9) of the backplate.

COMMENTARY: If the connector must be mounted on the back of the backplate, the connector mounting hardware shall be within the limits shown in Figure 13G to avoid possible interference with the mating LRU connector (see Paragraph 5.3.5.1).

5.3.5.2.1 Backplate Connector Positions. The connector position shall be as shown in Figures 9 and 10, as defined by Datum G' and Datum K. The spacings between connectors mounted on a common backplate is given in Figure 7.

5.3.5.2.2 Backplate Deflection. The perpendicularity requirements of Figures 9 and 10 shall be met when all equipment is installed.

5.4 Wire Integration. Wire integration is a function rather than a specific separate item of hardware. It is implemented as a part of the airframe wiring and the specific form it takes depends largely on the wiring techniques employed by the airframe manufacturer. However, some aspects of wire integration are discussed below.

5.4.1 Mechanical Interface Considerations

5.4.1.1 The wire integration center shall be located on the rack or airframe structure in such a way that it is accessible for test, checkout, repair, removal, and retrofit without removal of any other equipment or pieces of the aircraft.

5.4.1.2 The electrical terminations used for the wire integration center shall be protected from inadvertent contact with foreign materials and liquids which create unwanted electrical circuits. An easily removable protective cover shall be provided. Fluid drainage shall be provided.

5.4.1.3 Wire integration shall not impede the ability to replace the connector on a rack backplate. When a defective backplate connector is being replaced, there shall be minimal disturbance of the circuits not directly associated with that connector (includes need for removal of adjacent LRUs).

5.4.1.4 Connectors which are associated with wire integration shall be indexed or keyed to prevent inadvertent misconnection.

5.4.2 Electrical Interface Considerations

5.4.2.1 The wire integration center shall not use customized connectors and contact systems.

5.4.2.2 Each circuit which goes through the wire integration center shall be individually identifiable and accessible so that it can be intercepted for repair, test, reassignment, etc., with minimum disturbance to any other circuit.

5.4.2.3 The wire integration center shall be designed to accommodate a mixture of "straight through" circuits and "fanned out paralleled" circuits.

5.4.2.4 The wire integration center shall include provision for physical barriers required by circuit separation.

5.4.2.5 Where the wire integration is accomplished on a separate removable unit, provision shall be made to ensure that proper grounding of circuits can be accomplished and that, when there is a current of 10 Amps DC, a voltage drop of less than 2.5 millivolts between the ground part and structure is achieved.

5.4.3 Tooling and Maintenance Considerations. All of the tooling and maintenance considerations of Section 5.3.4 apply to the wire integration unit.

5.5 Thermal Management

5.5.1 Thermal Design Condition. The thermal design condition is the environmental and electrical operating mode to be used as the basic design condition for the equipment.

The thermal design condition represents normal operation of the equipment as installed in a military aircraft. For the test and design computational purposes herein, the thermal design condition is defined as follows:

(a) Equipment in the steady-state thermal condition (see Stabilization, 3.9).

(b) Equipment in the electrical operating mode which will yield the maximum steady-state heat dissipation.

(c) Ambient pressure at sea level. The local ambient pressure is acceptable provided it is noted in the test report.

(d) Ambient temperature, except for variations caused by (e) below, at 71°C.

(e) Air velocities immediately surrounding the equipment not greater than those caused by air movement due to natural (free) convection effects.

(f) Coolant air bulk inlet temperature at 15.5°C and 40°C.

(g) Coolant airflow rate in accordance with the schedule given in Figure 14 based on actual heat dissipation at condition (b) above.

(h) Inlet coolant air relative humidity not greater than 40 percent.

(i) Equipment located in surrounding and supporting structure which simulates standard in-service usage including adjacent units with surface temperatures of 71°C and minimum emissivities of 0.85 (see also Appendix I).

5.5.2 Electronic Part Application. This section is advisory in nature to caution the manufacturers of avionics equipments regarding the problems associated with electrical and electronic parts applications. To achieve electro/thermal stress levels consistent with desired performance and reliability, electronic part temperature shall be limited as follows:

Operating Condition	Part Junction Temperature	
	Microcircuits	Power Devices
Normal	105°C	120°C
Abnormal	125°C	150°C

COMMENTARY: The maximum predicted part temperature shall also take into account the effect of temperature of adjacent parts as well as the ambient air.

5.5.3 Ambient Temperature. This is the ambient air temperature immediately surrounding the equipment rack. For test purposes, ambient temperature is measured 75 mm in front of the LRU.

(a) Ground Survival Temperature, non-operating

-62°C to 95°C

NOTE: These are the lowest and highest ground temperatures expected to be experienced by equipment during aircraft storage or exposure to climatic extremes with power off. Equipment is not expected to be capable of operation at these temperatures, but to survive them without damage.

(b) Short Term Operating Temperature, 30 Minutes Duration -54°C to 95°C at sea level

(c) Low and High Operating Temperature, Ground or Flight

-54°C to 71°C

5.5.4 Coolant Air. Coolant air shall be supplied to LRUs installed in an aircraft in accordance with the design requirements of MIL-E-87145. The coolant air characteristics shall be as follows:

5.5.4.1 Coolant Air, Bulk Temperature at the LRU Inlet, Minimum to Maximum

Transient -54°C to 71°C (10 minutes)

Normal -54°C to 40°C (continuous)

NOTE: The design temperature selected for electrical component derating in accordance with the part application guidelines of 5.5.2. shall be "worst case" within the range 15.5°C to 40°C

5.5.4.2 <u>Coolant Air Flow Rate</u>. Cooling air is to be supplied to each equipment in proportion to the equipment's steady-state heat dissipation, defined per 3.10. The design airflow rate shall be in accordance with the mass flow versus inlet bulk temperature relationship shown in Figure 14.

5.5.4.3 <u>Coolant Air Pressure Drop Through the LRU</u>. The coolant air static pressure drop through the equipment shall be 50.5 $\pm$ 5 mm of water at the rated flow rate of air at 15.5°C, at sea level. This pressure drop does not include the drop through a metering orifice when such orifice is located external to the equipment case (e.g., in a rack-mounted equipment tray). For test purposes, at laboratory ambient pressure other than standard, corrections are allowed.

5.5.4.4 <u>Coolant Air Leakage from the Equipment</u>.

(a) The air leakage rate from the LRU heat exchangers at a static pressure differential of 50 mm of water gauge shall not exceed 2% of the design flow rate specified for 15.5°C cooling air at sea level.

(b) The leak rate at the Rack/LRU interface, at a static pressure differential of 50 mm water gauge shall not exceed 2% of the design flow rate specified for 15.5°C cooling air at sea level.

5.5.4.5 <u>Coolant Air Humidity</u>. Under ECS fault conditions the coolant air can contain up to 23 grams of water per kilogram of dry air.

5.5.4.6 <u>Coolant Air Contamination</u>. The cooling air shall not contain contaminant particles in excess of 400 m (microns).

5.5.4.7 <u>Coolant Air Inlet and Outlet Locations</u>. The coolant air shall enter the equipment through the rear surface only. This shall be accomplished by blowing the air. The exhaust cooling air shall exit via ports in the front face of the LRU.

5.5.5 <u>LRU Surface Temperature</u>. Under the thermal design conditions specified in 5.5.1, the average temperature of any LRU surface shall not exceed 71°C.

<u>Commentary</u>: This requirement is intended to define and limit the maximum radiant and convective heat load that one LRU can impose upon its neighbors and upon other adjacent surfaces. This is not a human factors requirement.

5.5.6 <u>LRU Thermal Appraisal</u>. The LRU shall meet the minimum standards of thermal design defined in Appendix I. This shall be demonstrated and documented in a thermal appraisal report intended to show that temperatures remain within the limits set forth.

5.5.6.1 <u>Identification and Data Tabulation for Heat Dissipating and Temperature Critical Parts</u>

(a) <u>Description</u>. Identification of the part type shall be presented under a column headed "description"; e.g., RL07 resistor, 2N2484 transistor, IN746 diode, CKR05 capacitor, etc. The term part shall include encapsulated assemblies.

(b) <u>Schematic Identification</u>. The tabulated data shall include the schematic symbol for each part; e.g., R106, Q127, V701, etc.

(c) <u>Location</u>. A general description of the part shall be provided.

(d) <u>Manufacturer's Maximum Rated Operating Dissipation</u>. May be the absolute maximum recommended by the part manufacturer or may be some upper limit less than the absolute maximum operating dissipation established by the equipment manufacturer.

(e) <u>Heat Dissipation</u>. The value for the rate of energy, in watts, being dissipated by the part during operation at the thermal design condition (as defined in 5.5.1) shall be tabulated.

Preferably this value shall be the result of measured data, but it may be determined through calculations.

(f) Junction Temperature (T_J). Calculation and supporting test results to show compliance with 5.5.2 and MIL-HDBK-217 guidance material.

(g) Maximum Surface Temperature (T_M). This is the absolute maximum surface temperature allowable in the above (e) mode of operation as determined by the component manufacturer's specification.

(h) Design Surface Temperature (T_C). The design surface temperature is defined as the maximum external surface temperature that can be tolerated consistent with the part's function and system or equipment specified reliability requirement at the thermal design condition. The value for this temperature and its location on each part shall be tabulated for each part. For electrical parts, the design surface temperature shall be determined as outlined in 5.5.2, Electronic Part Application.

NOTE: Parts which are encapsulated assemblies of basic component parts shall have their maximum and design surface temperatures tabulated. The thermal relationship between the parts in the encapsulation and the encapsulated assembly surface shall be reported in sufficient detail to allow the prediction of the internal part temperatures from the measured encapsulated assembly surface temperature.

5.5.6.2 Thermal Evaluation Test. An engineering development thermal evaluation test shall be conducted on a thermally representative LRU in accordance with the procedure of Appendix I. This test shall be performed prior to qualification testing in order to assess the LRU's thermal design, and its cooling needs. The evaluation shall determine for operation at elevated temperature (1) the equipment total heat dissipation, (2) the pressure drop versus airflow relationship, and (3) the temperature of equipment sidewalls and selected internal parts.

The LRU design shall meet or exceed the minimum standards of thermal performance when tested for coolant airflow as outlined in the Thermal Evaluation Test Acceptance Criteria of Appendix I.

5.5.7 Thermal Interface Information. The following information shall be supplied with the Equipment Installation and Control Drawing:

(a) Total wattage input and actual heat dissipation for all modes of electrical operation for which the equipment was designed; e.g., standby, receiving, transmitting, etc.

(b) Estimated in-flight and ground maximum duty cycle (when specified).

(c) Pressure drop through the unit in mm of water when the ambient pressure is at sea level and,

(1) Coolant inlet temperature is $40^{\circ}C$ at a flow rate of 120 kg hr^{-1}. kW^{-1}.

(2) Coolant inlet temperature is $15.5^{\circ}C$ at a flow rate of 65 kg hr^{-1}. kW^{-1}.

(3) Coolant inlet temperature is $-18^{\circ}C$ at a flow rate of 40 kg hr^{-1}. kW^{-1}.

(d) Average temperature of equipment sidewalls at the thermal design condition.

(e) Effect of dry contamination on unit cooling performance and recommended unit service intervals required to maintain cooling performance, if applicable.

(f) Analytical effect on the LRU reliability prediction (reference MIL-STD-454, Requirement 35 and MIL-HDBK-217) of a $\pm 25\%$ variation in the coolant inlet rate of flow from the design condition of 5.5.4.1.

5.6 Power Quality and Power Conditioning. An electrical interface section is included in this specification to provide guidance information to the equipment engineer regarding

(a) The characteristics of the aircraft electrical power available to the LRU at the equipment rack, and

(b) Conversion and conditioning of this power for use within the LRU.

5.6.1 Power Quality. Each aircraft electrical power quality specification may vary slightly with regard to specific parameter being observed and values assigned to that parameter under various operating conditions. However, it is generally accepted that, in the vast majority of aircraft, no problems due to input power quality will be encountered by LRUs/equipment which have been designed to meet MIL-STD-704C plus the voltage spike conducted tests of MIL-STD-461.

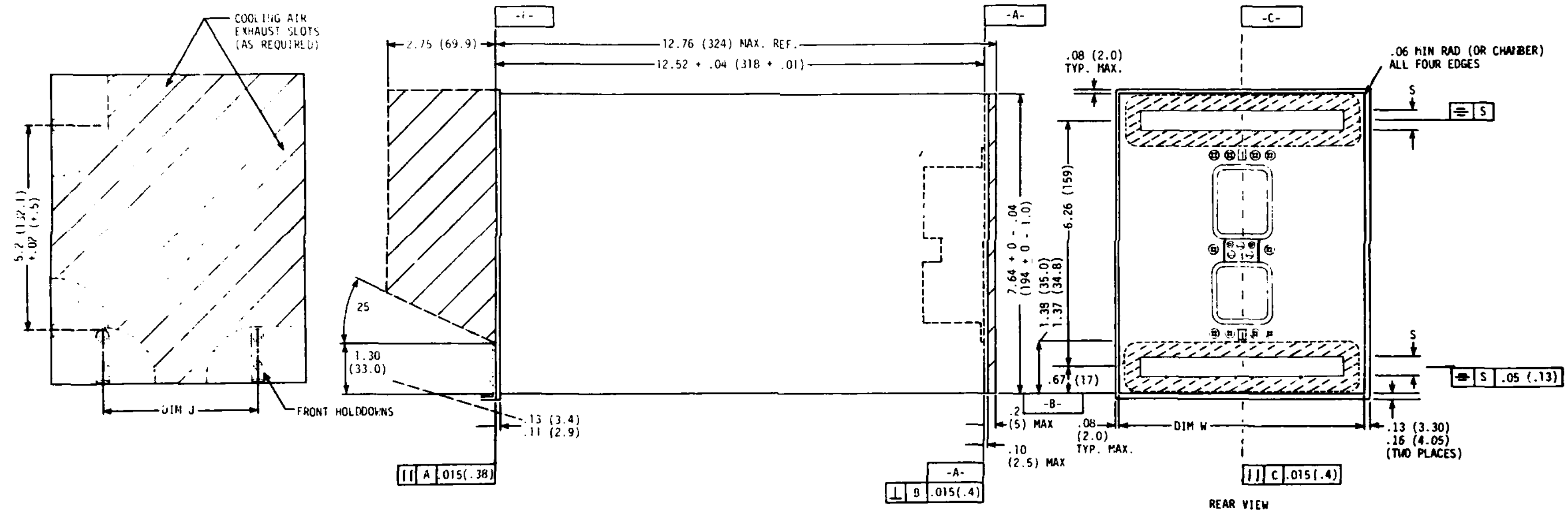
Therefore, for the purpose of this specification, the electrical power interface at the equipment rack will be considered as defined by the details of MIL-STD-704C.

5.6.2 Power Conditioning. All conversion and/or conditioning of power to obtain desired frequency, level of voltage, or quality of power will be accomplished within the LRU or by the subsystem of which the LRU is a part. Design of the power conditioning section shall minimize the thermal losses, and control the effect of conducted and radiated interference.

5.7 Mechanical and Structural Evaluation. The rack, tray, or mounting base manufacturer shall show by analysis and/or test that the rack will meet the deflection and bending requirements under specified conditions of load, and that the rack has required strength to resist all operational stresses, in accordance with 5.2.2.

The aircraft cooling system shall be tested to demonstrate that the required airflow rates are achieved at the specified inlet temperatures, in accordance with 5.5.4.

The LRU manufacturer shall show by analysis and test that the unit meets weight, vibration, and acceleration requirements in accordance with 5.1.1.4, 5.1.6.4, and 5.1.6.5. A mechanical evaluation test program in accordance with Appendix 2 shall be an integral part of LRU development. The vibration qualification test sequence shall be one-half hour at performance level, one hour at endurance level, followed by one-half hour at performance level, in each of three orthogonal axes. Test levels are defined in Figure 5.

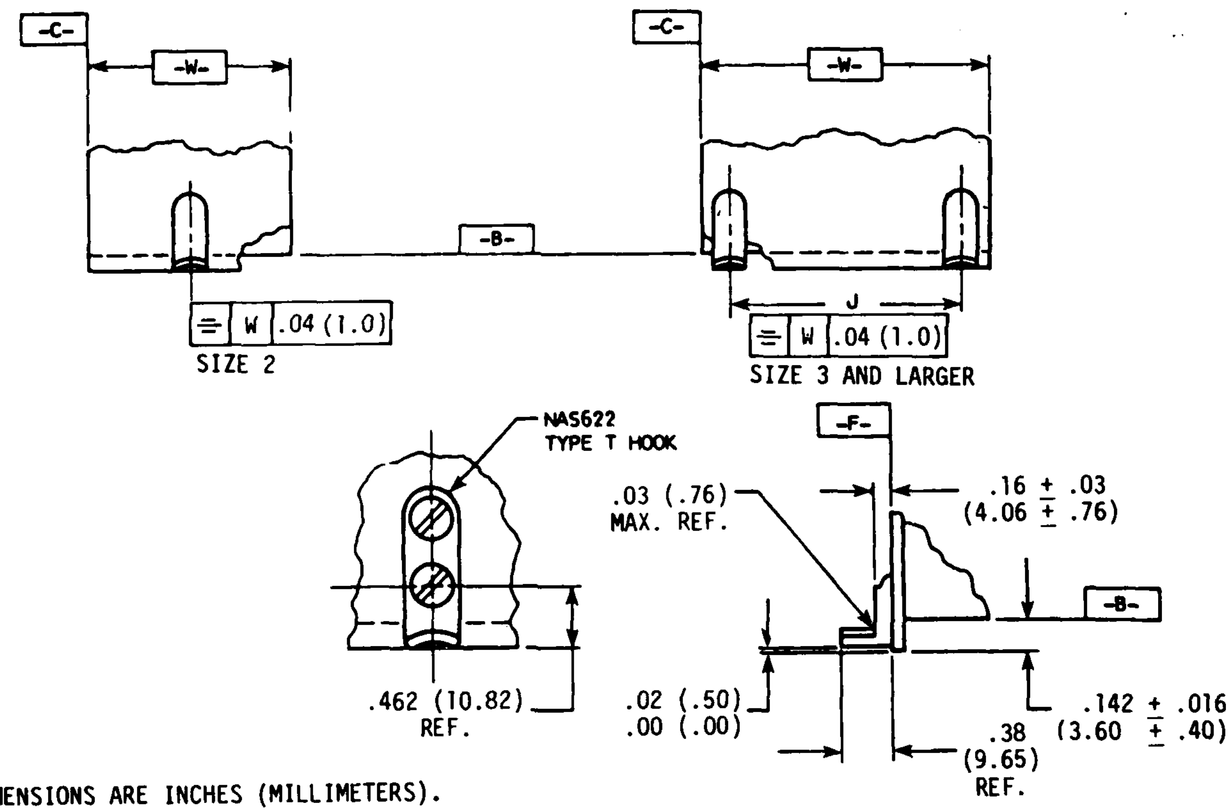


NOTE: DIMENSIONS ARE INCHES (MILLIMETERS).

NOTE: FOR OTHER BACKPLATE CONFIGURATIONS, SEE FIGURE 3.

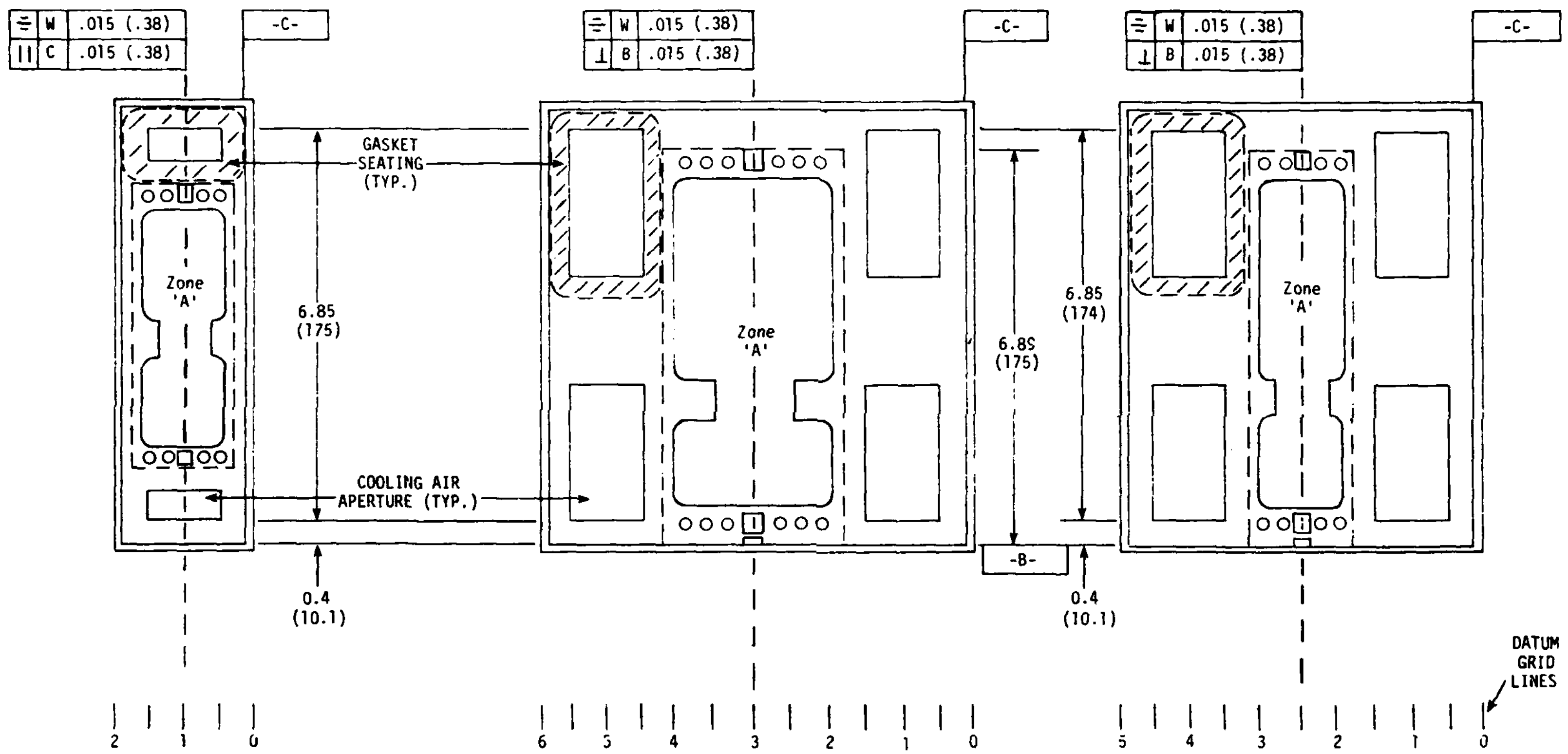
FIGURE 1 - STANDARD LRU CASE

LRU SIZE	3 MCU	4 MCU	5 MCU	6 MCU	7 MCU	8 MCU	9 MCU	10 MCU	11 MCU	12 MCU
DIM J ± .02 IN.	2.60	2.60	3.90	5.20	6.50	7.80	9.10	10.40	11.70	13.00
DIM J ± .5 MM	66.0	66.0	99.1	132.1	165.1	198.1	231.1	264.2	297.2	330.2



NOTE: DIMENSIONS ARE INCHES (MILLIMETERS).

FIGURE 2 - LRU HOLDDOWN MECHANISM



NOTE: DIMENSIONS ARE INCHES (MILLIMETERS).

FIGURE 3 - LOCATION OF CONNECTOR AND COOLING AIR APERTURES

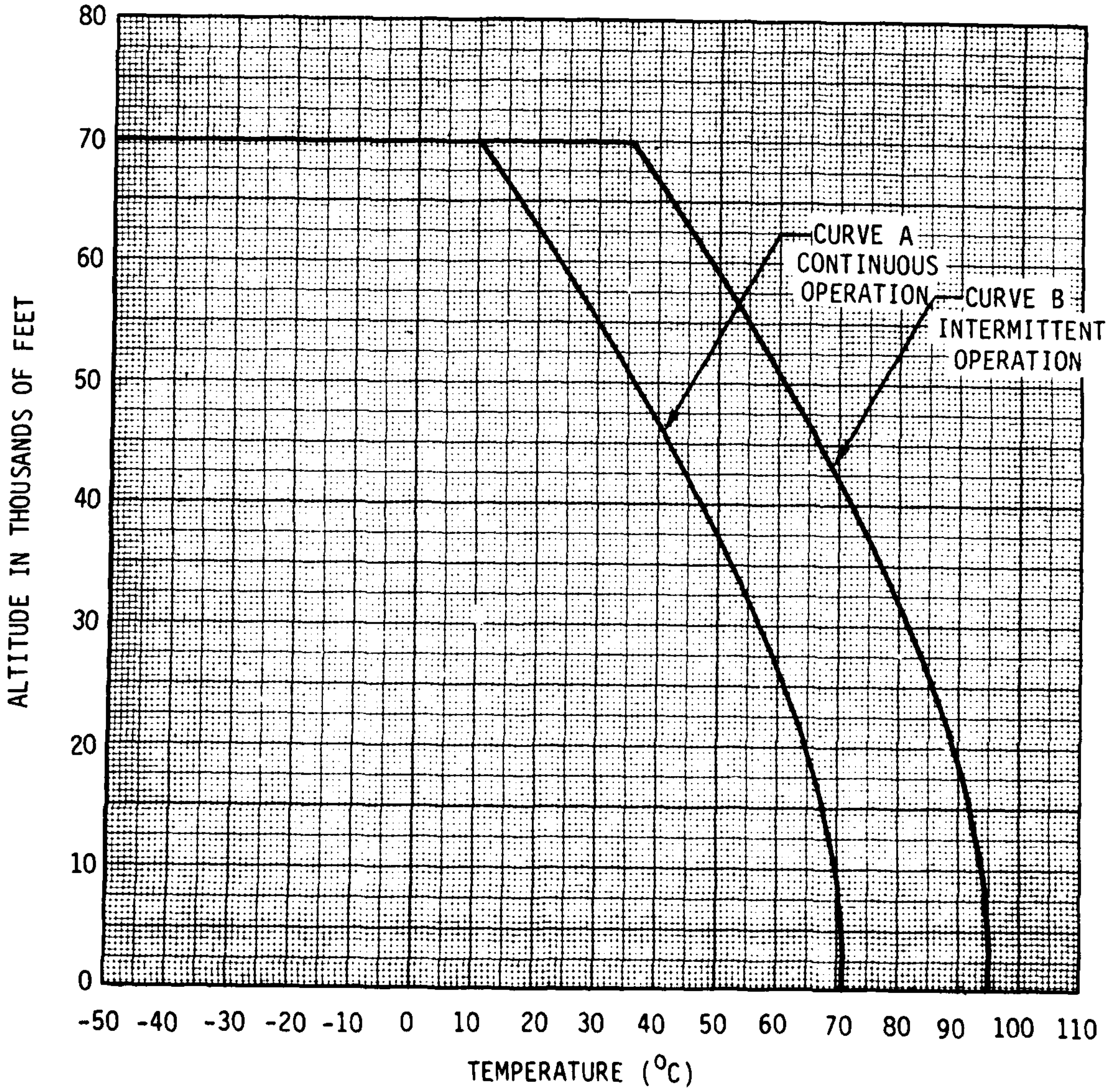


FIGURE 4 - TEMPERATURE/ALTITUDE ENVIRONMENT

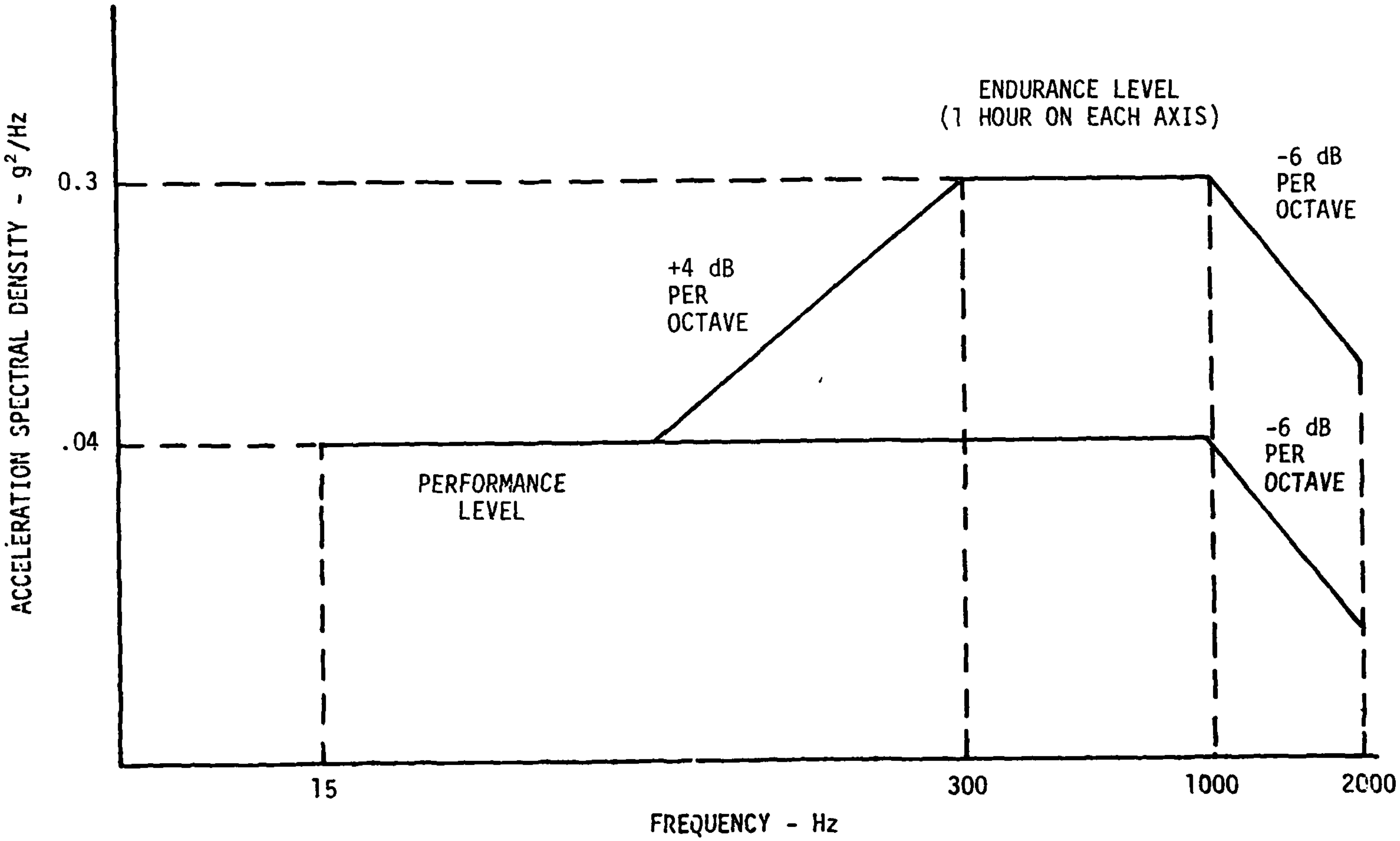


FIGURE 5 - VIBRATION TEST REQUIREMENTS

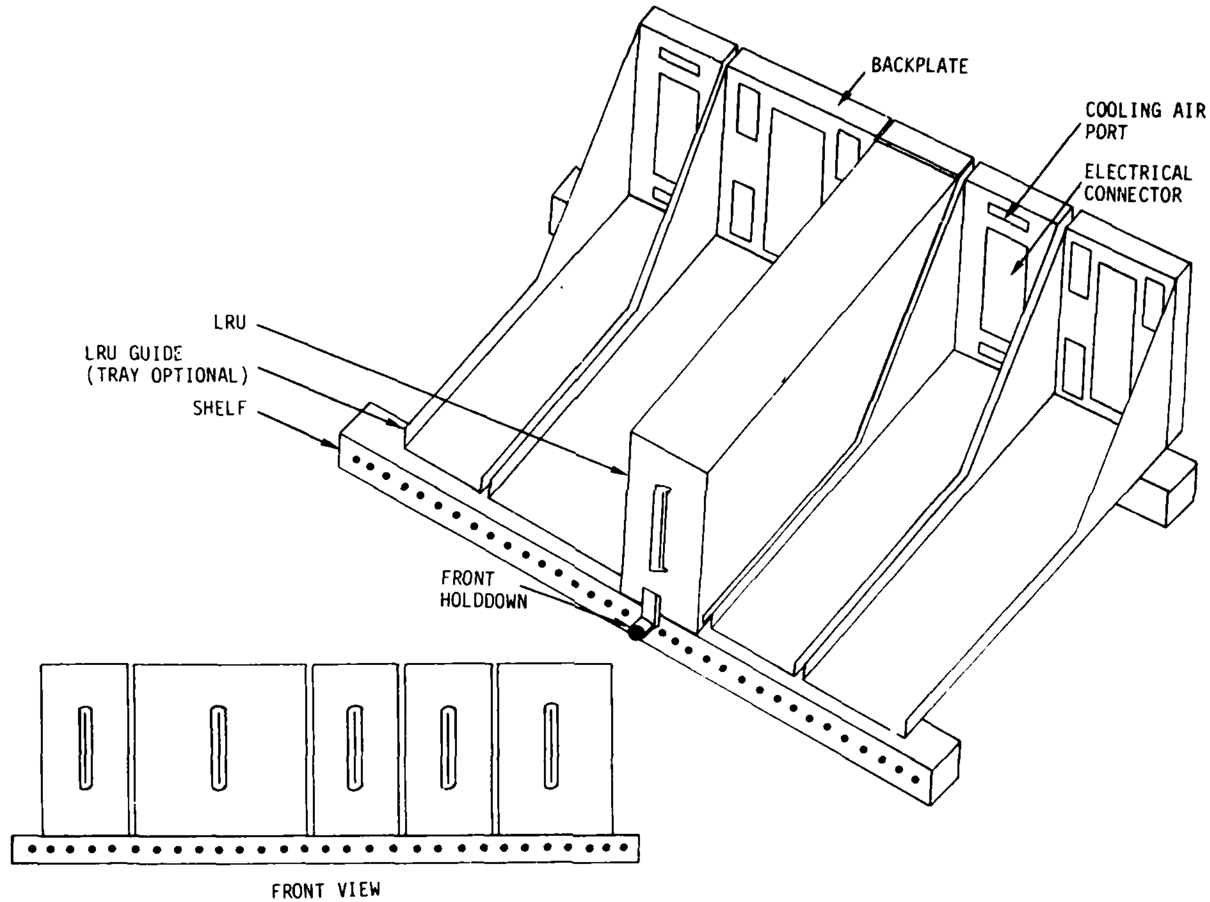
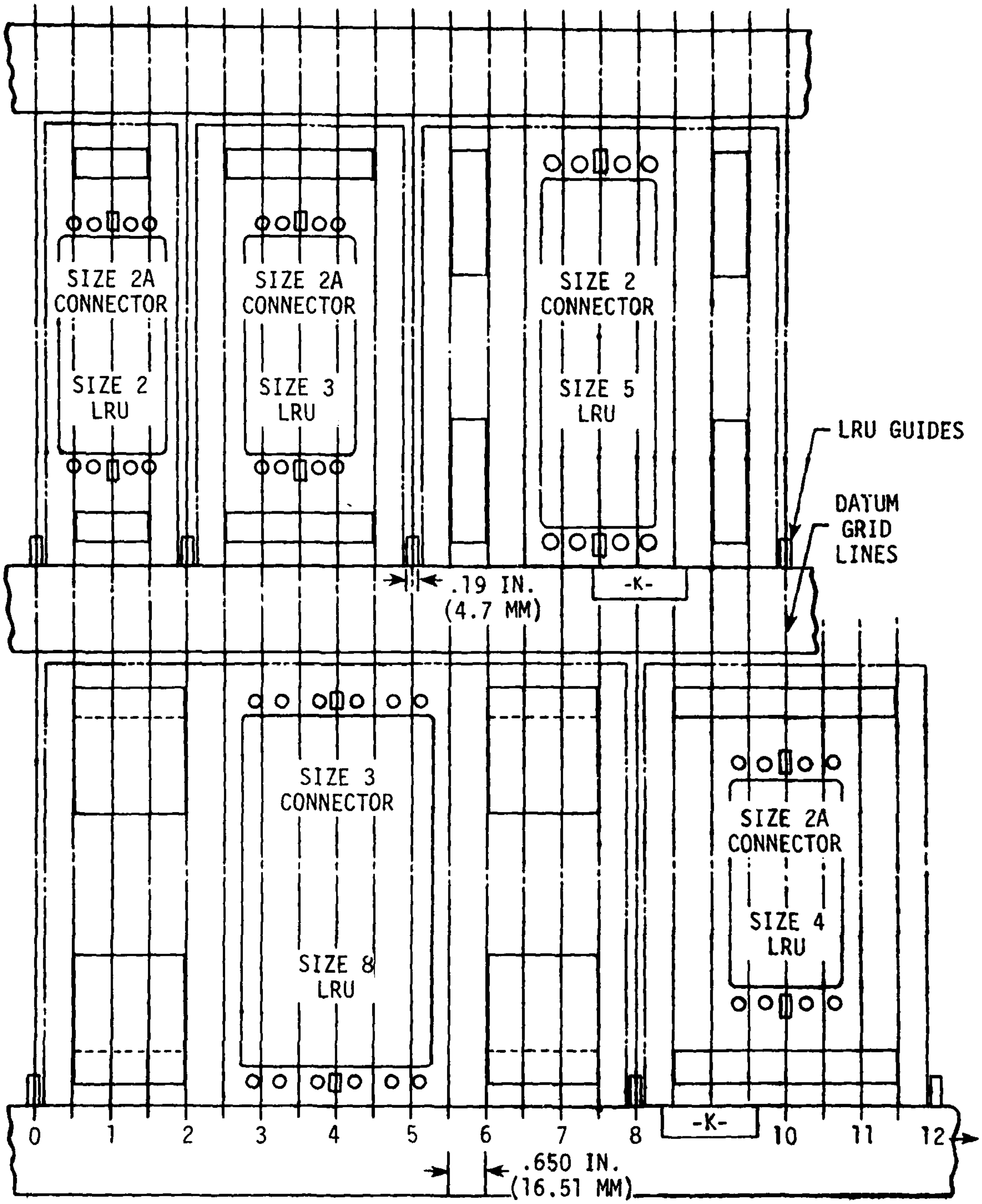


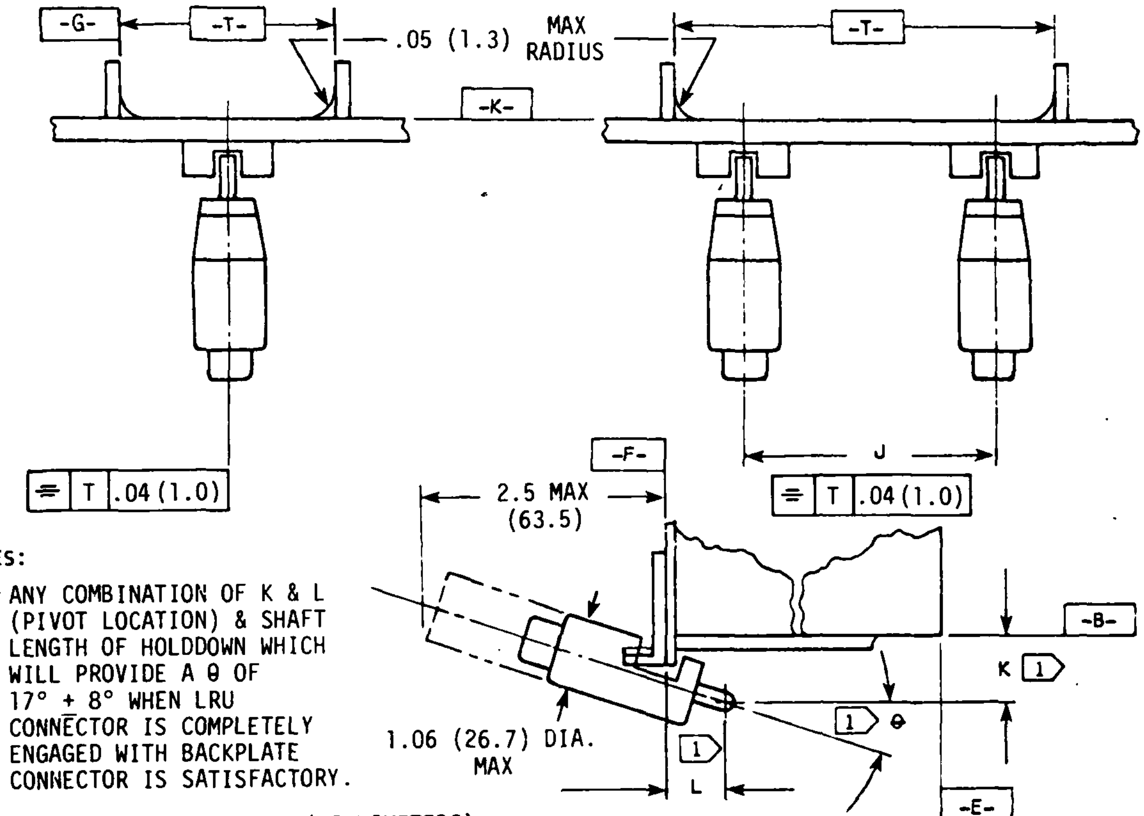
FIGURE 6 - TYPICAL RACK ASSEMBLY



NOTE: DIMENSIONS ARE INCHES (MILLIMETERS).

FIGURE 7 - STANDARD SHELF DATUM LINE GRID AND LRU LOCATION

UNIT SIZE (MCU)	2	3	4	5	6	7	8	9	10	11	12
DIM J ± .02 IN.	0.00	2.60	2.60	3.90	5.20	6.50	7.80	9.10	10.40	11.70	13.00
DIM J ± .5 MM	0.00	66.0	66.0	99.1	132.1	165.1	198.1	231.1	264.2	297.2	330.2
DIM T ± .010 IN.	2.39	3.69	5.01	6.31	7.61	8.91	10.21	11.51	12.81	14.11	15.41
DIM T ± .3 MM	60.7	93.7	127.3	160.3	193.3	226.3	259.3	292.4	325.4	358.4	391.4

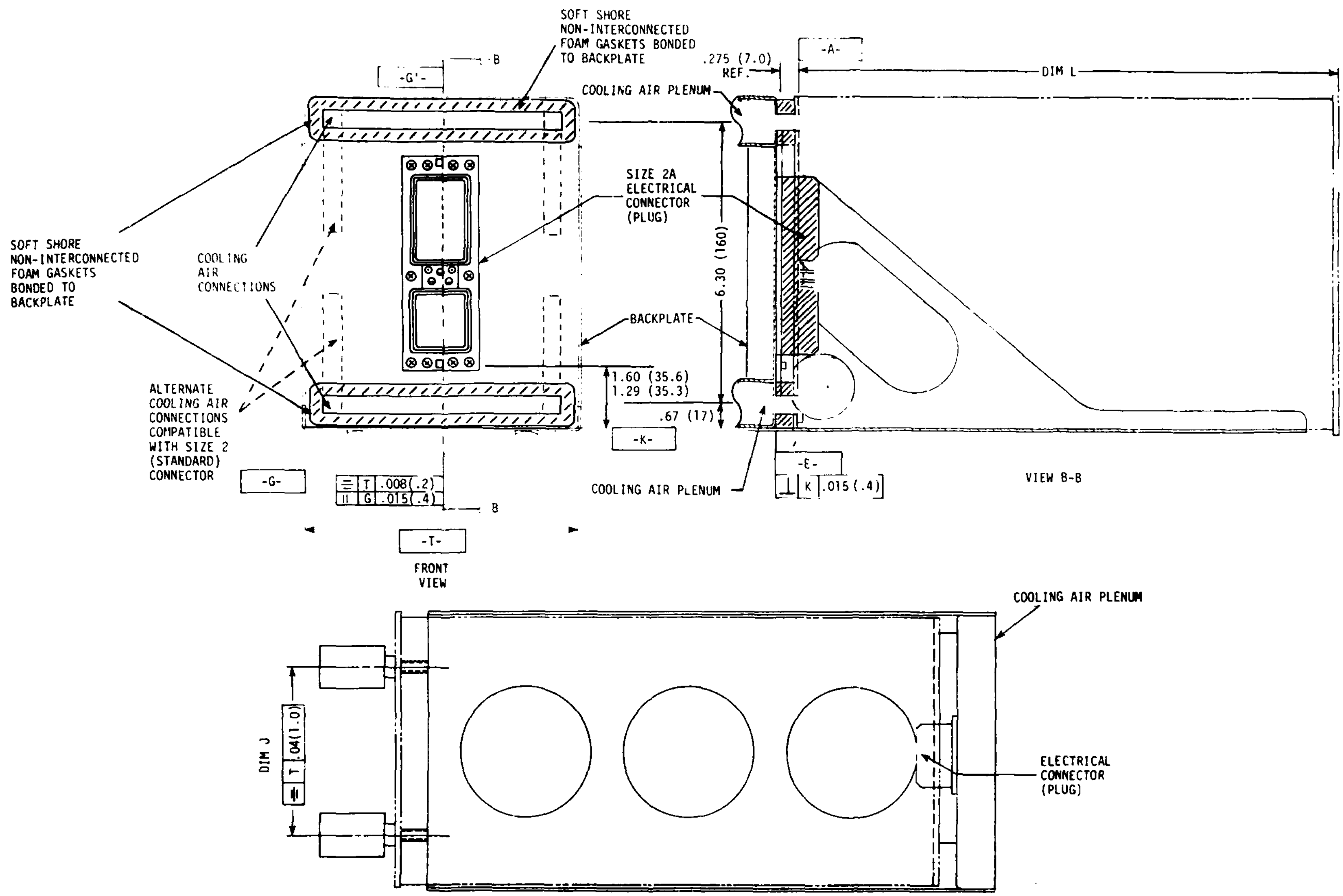


NOTES:

1. ANY COMBINATION OF K & L (PIVOT LOCATION) & SHAFT LENGTH OF HOLDDOWN WHICH WILL PROVIDE A θ OF 17° + 8° WHEN LRU CONNECTOR IS COMPLETELY ENGAGED WITH BACKPLATE CONNECTOR IS SATISFACTORY.

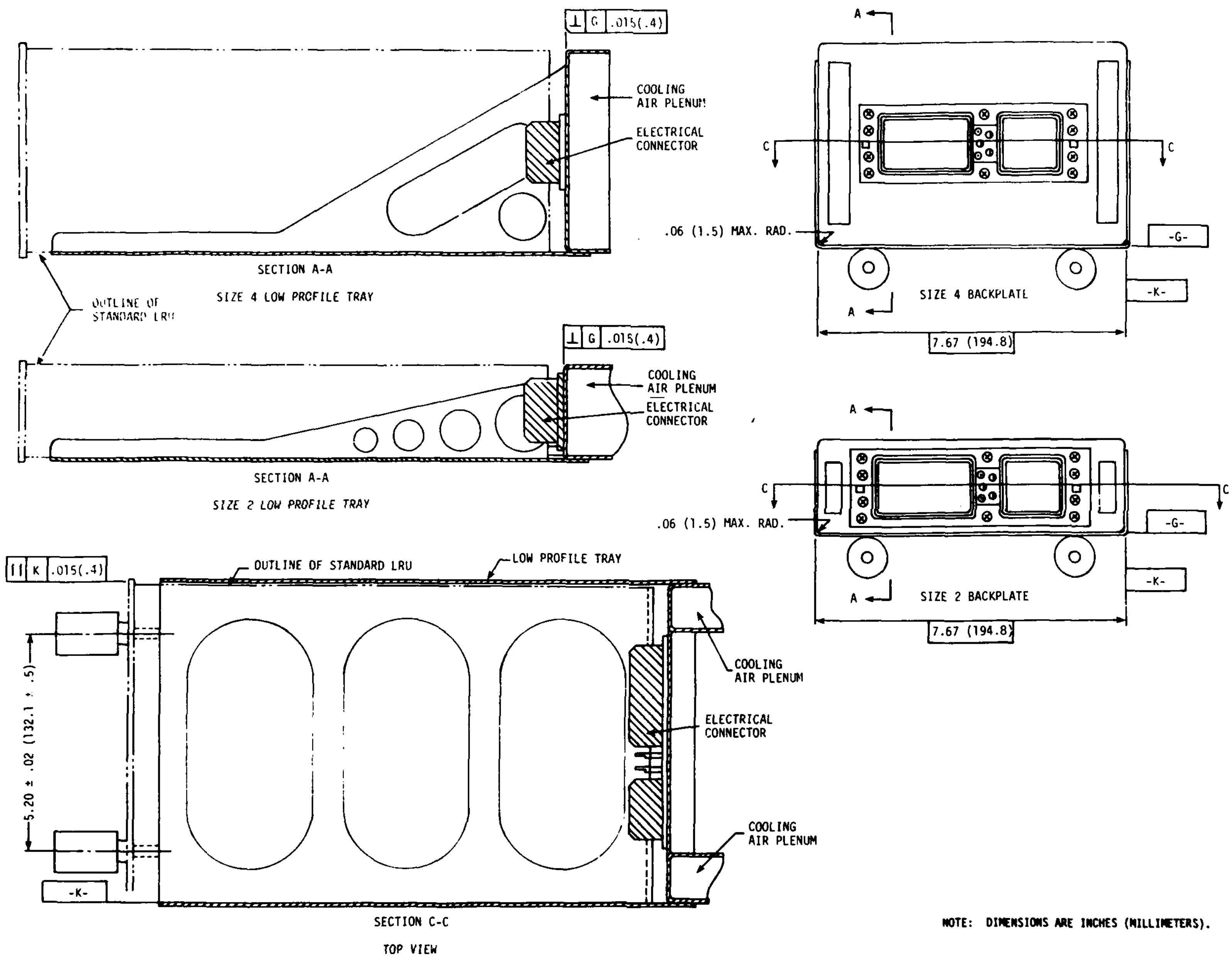
DIMENSIONS ARE INCHES (MILLIMETERS).

FIGURE 8 - LRU/RACK HOLDDOWN MECHANISM



NOTE: DIMENSIONS ARE INCHES (MILLIMETERS).

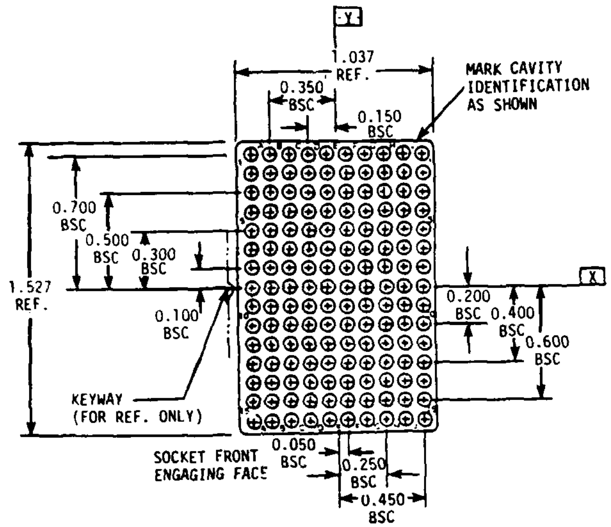
FIGURE 9 - RACK DATUMS, CONNECTOR, AND COOLING AIR INTERFACE



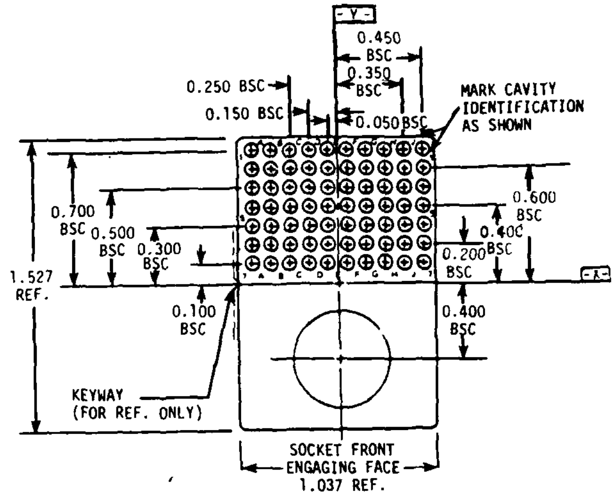
NOTE: DIMENSIONS ARE INCHES (MILLIMETERS).

FIGURE 10 - TYPICAL LOW PROFILE TRAYS

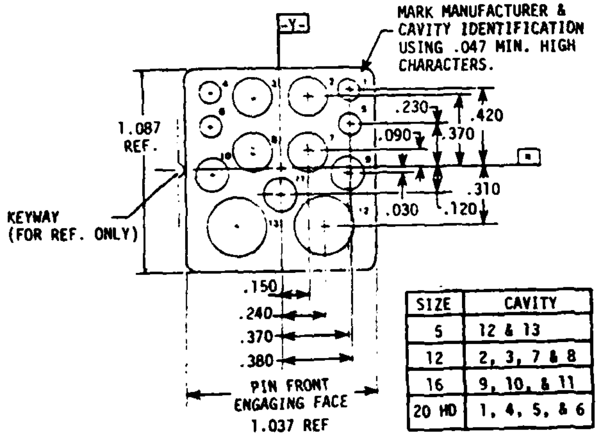
SIGNAL CONTACT ARRANGEMENT 02, SHELL SIZE 2 AND 3 CONNECTORS



CONTACT ARRANGEMENT 05, SIGNAL CONTACTS WITH SIZE 1 COAXIAL, SHELL SIZE 2 AND 3 CONNECTORS

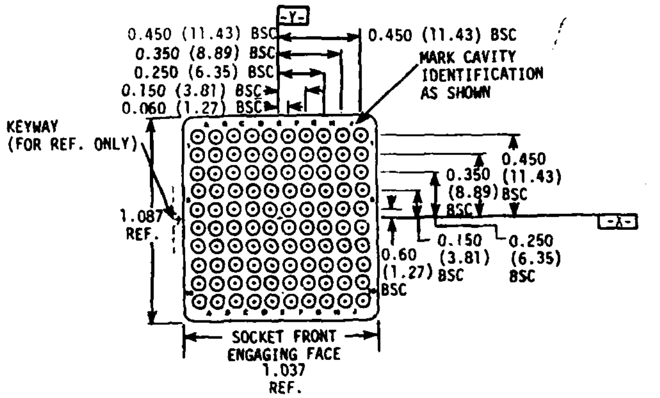


POWER/COAXIAL CONTACT ARRANGEMENT 04, SHELL SIZE 2 AND 3



SIZE	CAVITY
5	12 & 13
12	2, 3, 7 & 8
16	9, 10, & 11
20 HD	1, 4, 5, & 6

SIGNAL CONTACT ARRANGEMENT 07, SHELL SIZE 2 AND 3 CONNECTORS



INDEX PIN CODING

NOTES: DARKENED PORTION INDICATES EXTENDED PART OF POST IN PLUG. LIGHT PORTION INDICATES KEY HOLE IN RECEPTACLE.

MATING FACES SHOWN WITH TOP UP.

DIMENSIONS ARE INCHES (MILLIMETERS).

FIGURE 11 - LOWER CONTACT POSITION IDENTIFICATION INSERT SIZE AND INDEX PIN CODING

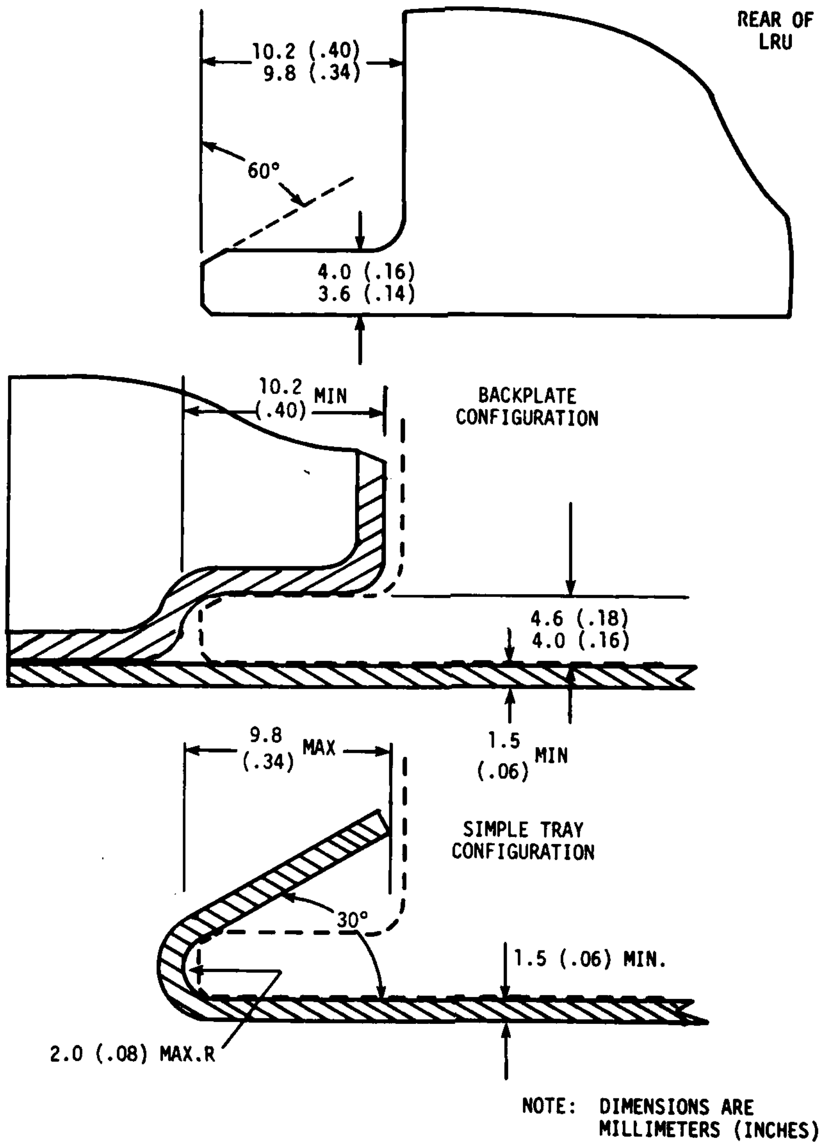
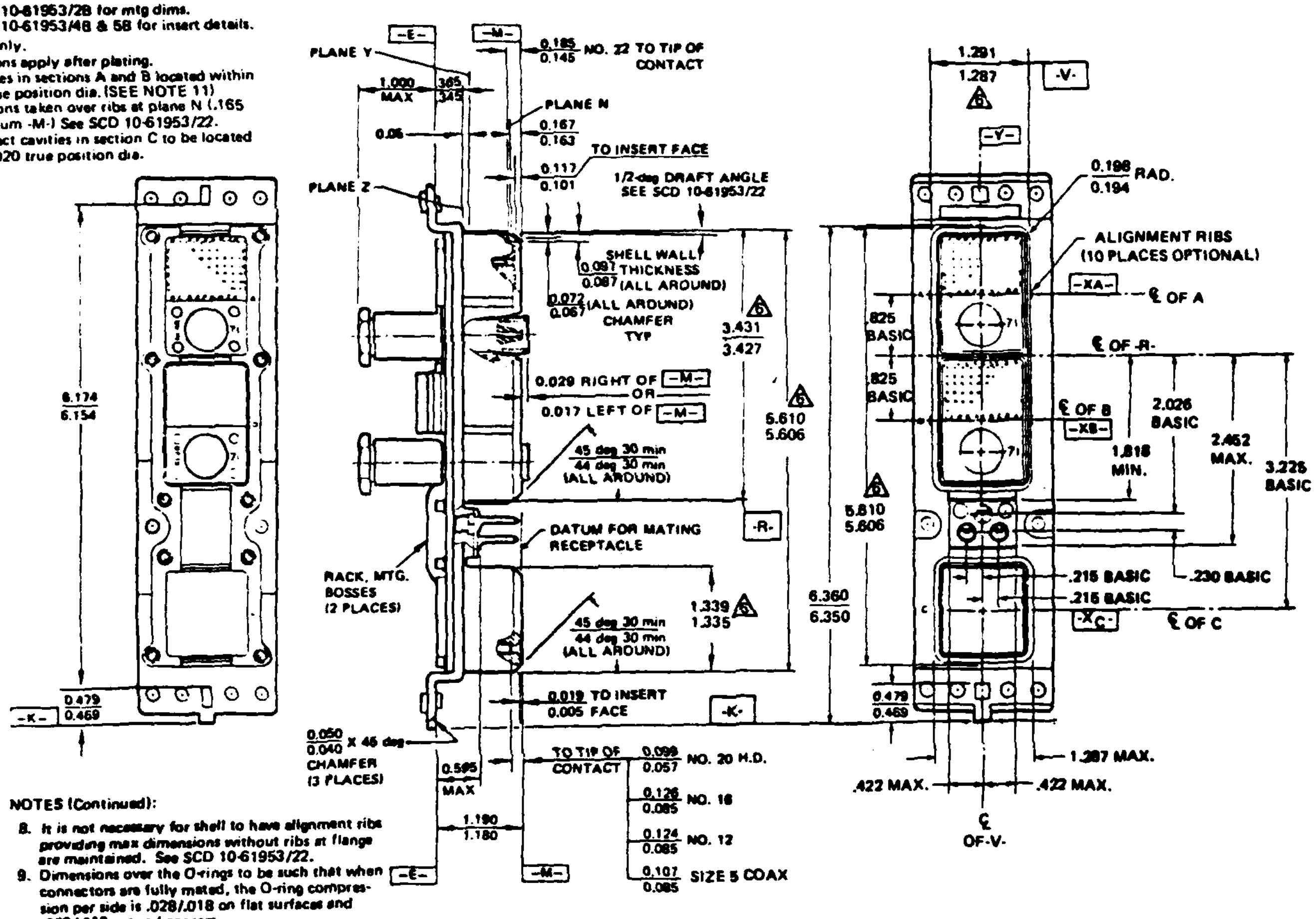


FIGURE 12 - ALTERNATE REAR HOLDDOWN

NOTES:

1. See SCD 10-61953/2B for mtg dims.
2. See SCD 10-61953/4B & 5B for insert details.
3. Class B only.
4. Dimensions apply after plating.
5. All cavities in sections A and B located within .006 true position dia. (SEE NOTE 11)
6. Dimensions taken over ribs at plane N (.165 from datum -M-) See SCD 10-61953/22.
7. All contact cavities in section C to be located within .020 true position dia.

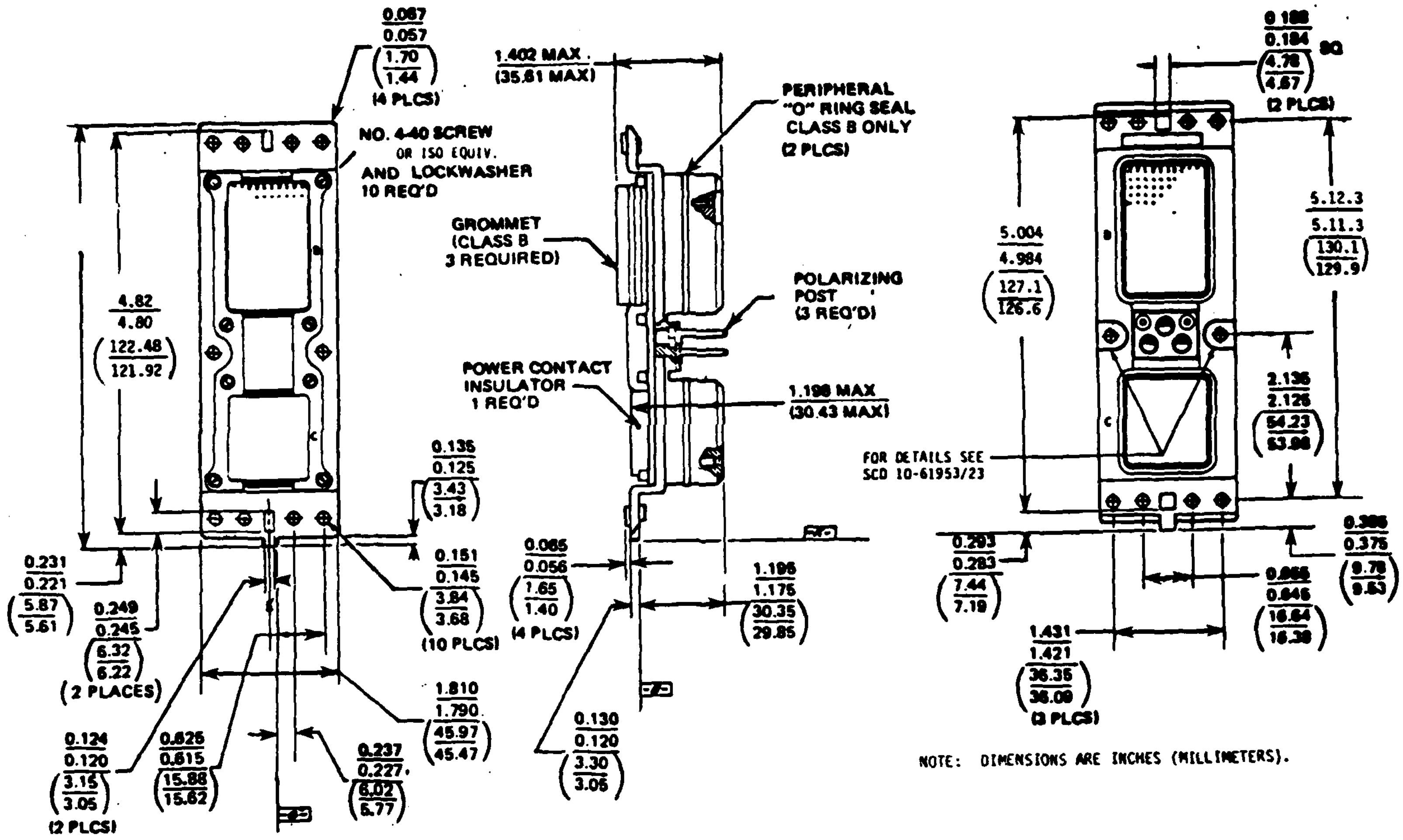


NOTES (Continued):

8. It is not necessary for shell to have alignment ribs providing max dimensions without ribs at flange are maintained. See SCD 10-61953/22.
9. Dimensions over the O-rings to be such that when connectors are fully mated, the O-ring compression per side is .028/.018 on flat surfaces and .023/.013 around corners.
10. O-ring sizes—environmental version
    Cavity location A-B M25988/3-142
    Cavity location C M25988/3-124
11. T. P. of .009 will be acceptable until 7/1/81.

NOTE: DIMENSIONS ARE INCHES.

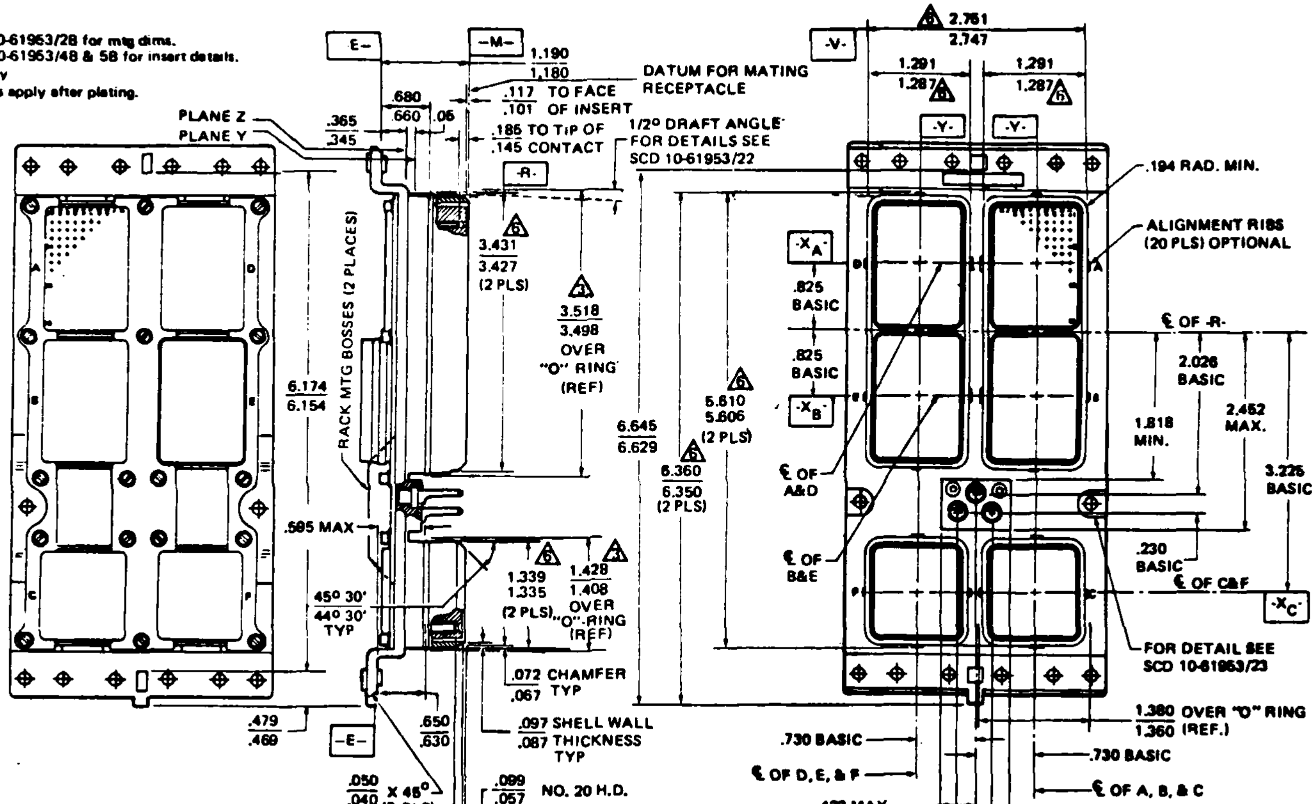
FIGURE 13A - SIZE 2 CONNECTOR PLUG



NOTE: DIMENSIONS ARE INCHES (MILLIMETERS).

FIGURE 13B - SIZE 2A CONNECTOR PLUG

NOTES:
1. See SCD 10-61953/28 for mtg dims.
2. See SCD 10-61953/48 & 58 for insert details.
3. Class B only
4. Dimensions apply after plating.



NOTES (Continued):

5. All cavities in sections A B D and E located within .006 true position dia. (SEE NOTE 11)
6. Dimensions taken over ribs at plane N (.165 from datum -M-) See SCD 10-61953/22.
7. All contact cavities in section C and F to be located within .020 true position dia.
8. It is not necessary for shell to have alignment ribs providing max dimensions without ribs at flange are maintained. See SCD 10-61953/22.

NOTES (Continued)

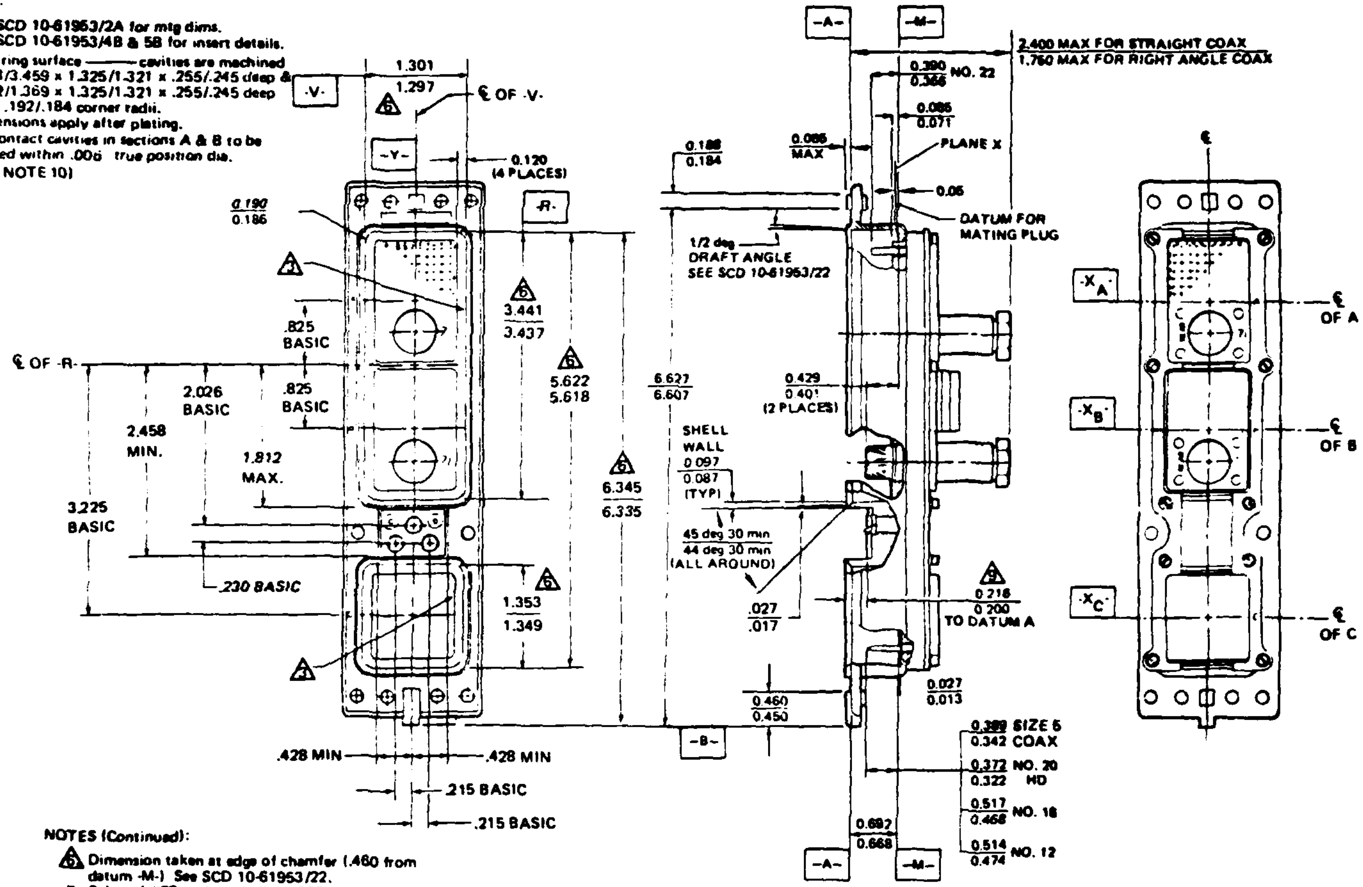
9. Dimensions over the O-rings to be such that when connectors are fully mated, the O-ring compression per side is .028/.018 on flat surfaces and .023/.013 around corners.
10. O-ring sizes—environmental version
Cavity location A-B M25988/3-142
Cavity location C M25988/3-124
11. T.P. of .009 will be acceptable until 7/1/81.
12. All contact cavities in insert arrangement 07 in Sections C and F to be located within .006 T.P.D.

NOTE: DIMENSIONS ARE INCHES.

FIGURE 13C - SIZE 3 CONNECTOR PLUG

NOTES.

1. See SCD 10-61953/2A for mtg dims.
2. See SCD 10-61953/4B & 5B for insert details.
3. "O" ring surface ——— cavities are machined 3.463/3.459 x 1.325/1.321 x .255/.245 deep & 1.372/1.369 x 1.325/1.321 x .255/.245 deep with .192/.184 corner radii.
4. Dimensions apply after plating.
5. All contact cavities in sections A & B to be located within .006 true position dia. (SEE NOTE 10)



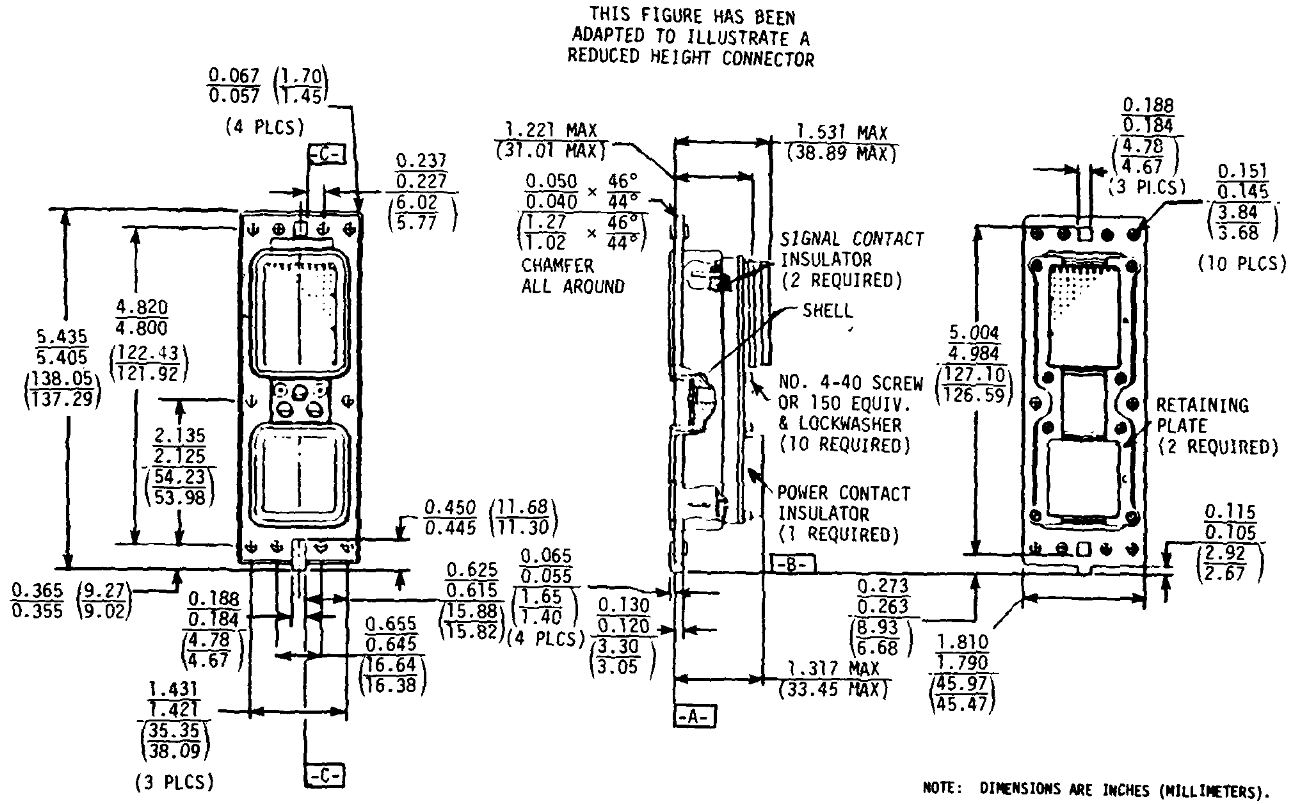
NOTES (Continued):

6. Dimension taken at edge of chamfer (.460 from datum -M-) See SCD 10-61953/22.
7. Splay of #22 sockets shall be .006 max. at tip of socket.
8. All contact cavities in section C to be located within .020 true position dia.
9. For shell size 3 connector, use 0.218/0.202—all other dimensional information on center view identical for shell size 3 connector.

10. T. P. of .009 will be acceptable until 7/1/81.

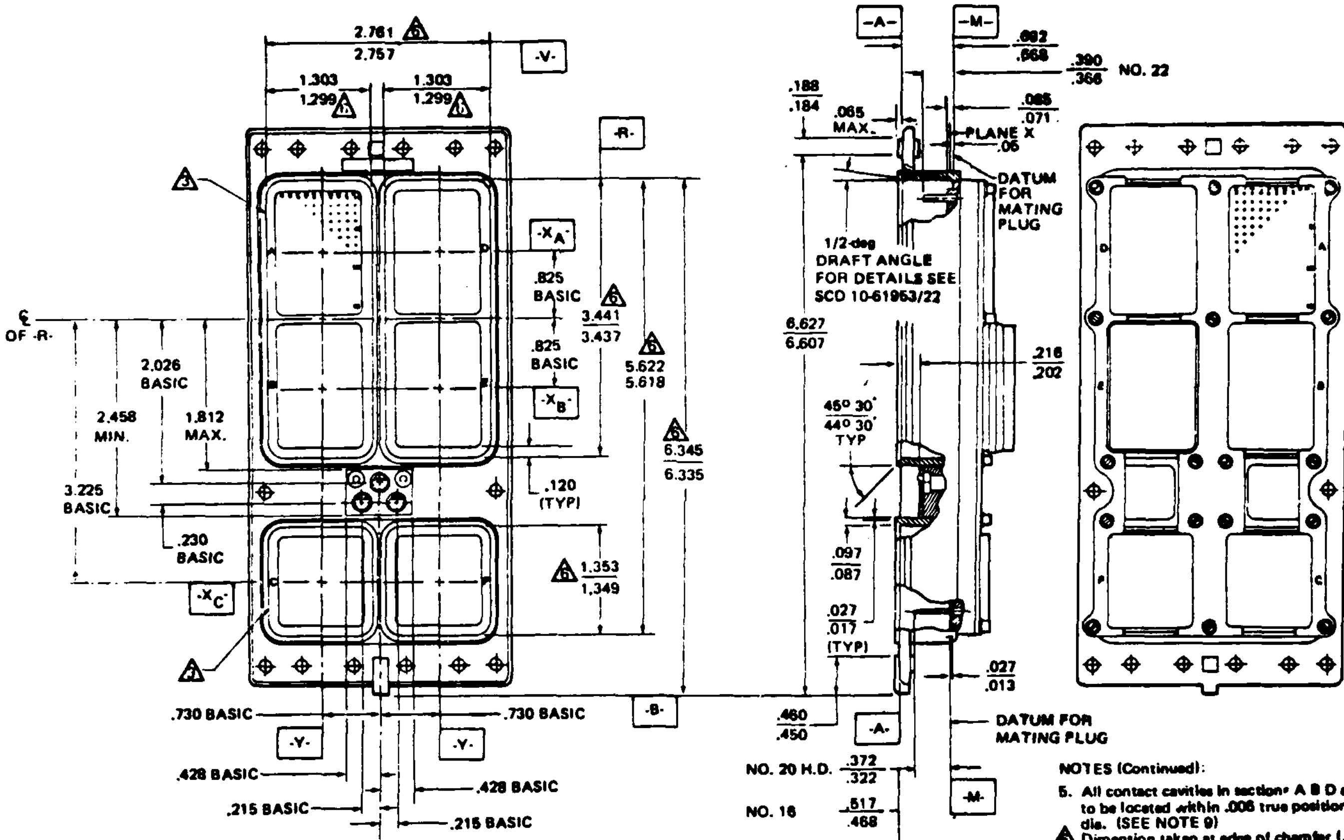
NOTE: DIMENSIONS ARE INCHES.

FIGURE 13D - SIZE 2 CONNECTOR RECEPTACLE



NOTE: DIMENSIONS ARE INCHES (MILLIMETERS).

FIGURE 13E - SIZE 2A CONNECTOR RECEPTACLE

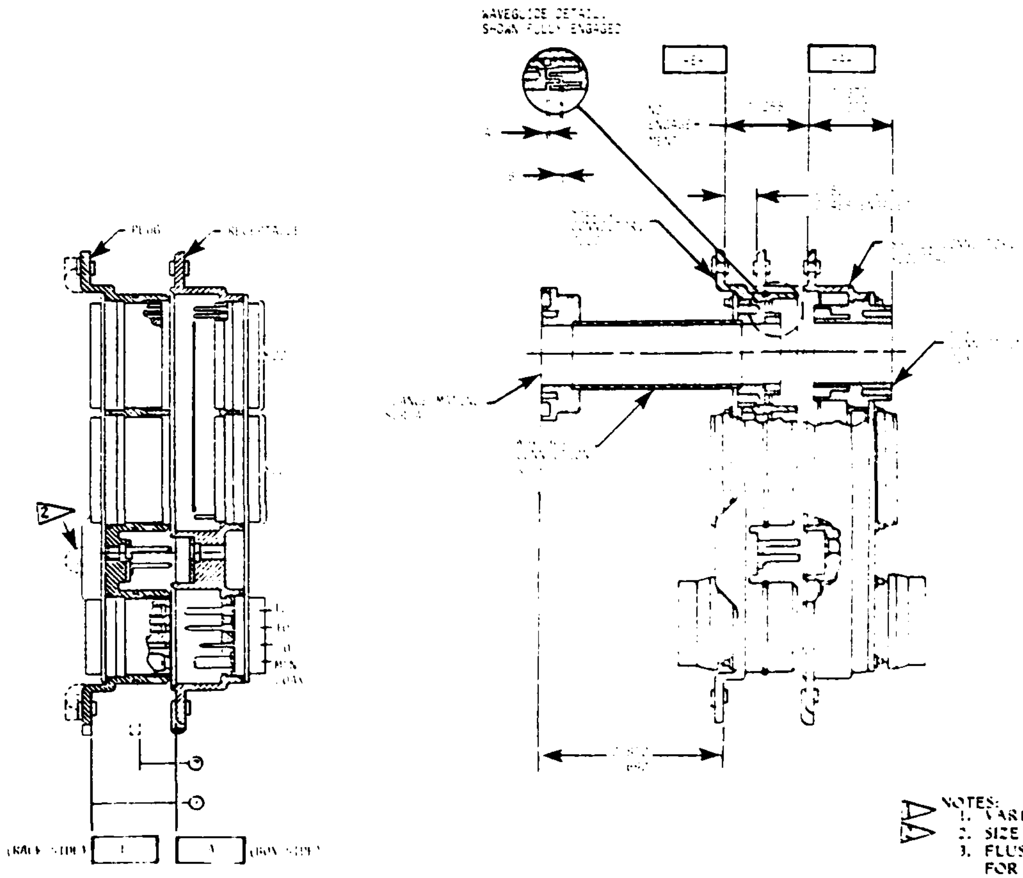


NOTES:
1. See SCD 10-61953/2A for mtg dims.
2. See SCD 10-61953/4B & 5B for insert details.
3. "O" ring surface ——— cavities are machined 3.463/3.459 x 1.325/1.321 x .255/.245 deep & 1.372/1.369 x 1.325/1.321 x 255/.245 deep & .192/.184 corner radii.
4. Dimensions apply after plating.

NOTES (Continued):
5. All contact cavities in sections A B D and E to be located within .006 true position dia. (SEE NOTE 9)
6. Dimension taken at edge of chamfer (.460 from datum -M-) See SCD 10-61953/22.
7. Splay of No. 22 sockets shall be .006 max at tip of socket.
8. All contact cavities in section C and F to be located within .020 true position dia.
9. T.P. of .009 will be acceptable until 7/1/81.
10. All contact cavities in insert arrangement 07 in sections C and F to be located within .006 T.P.D.

NOTE: DIMENSIONS ARE INCHES.

FIGURE 13F - SIZE 3 CONNECTOR RECEPTACLE



STANDARD

WITH WAVEGUIDE INSERT

MATING SEQUENCE	FLANGE POSITION WITH	FLANGE SPACING
(1)	NO ENGAGEMENT	[illegible]
(2)	SHELLS INITIALLY ENGAGED	[illegible]
(3)	POLARIZING PINS ENTERING KEYS	[illegible]
(4)	CONTACTS ENTERING MATING INSULATOR	
	#22	[illegible]
	#20	[illegible]
	#16	[illegible]
	#12	[illegible]
	MINIATURE COAX	1
(5)	CONTACTS ELECTRICALLY ENGAGED	
	#22	[illegible]
	#20	[illegible]
	#16	[illegible]
	#12	[illegible]
	MINIATURE COAX	1
(6)	REAR PANEL SEAL ENGAGEMENT (RACK ONLY)	[illegible]
(7)	SHELLS FULLY MATED	[illegible]

NOTES:
1. VARIES: SEE MIL SPEC
2. SIZE 1 ONLY
3. FLUSH HEAD SCREWS ARE NOT PERMITTED FOR CONNECTOR MOUNTING AS THEY WOULD POSITION CONNECTOR INCORRECTLY
4. DIMENSION " WAS CALCULATED TO PROVIDE CLEARANCE FOR
   - MCU BACKPLATE MAT'L THICKNESS OF 2.5 MM(.10 in) (See 3.1.1.3)
   - RACK BACKPLATE MAT'L THICKNESS OF 2.5 MM(.10 in)
   - CONNECTOR MOUNTING PAN HEAD SCREWS,MCU 2.0 MM (.08 in) RACK 2.0 MM (.08 in)
   - TOLERANCE ALLOWANCE - 3.2 MM (.13 in)
   (See "Commentary" under Section 3.1.1.3 Rear Panel)

   TOTAL - 12.2 MM (.50 in) (minimum)

FIGURE 13G - THE CONNECTOR AND ITS ENGAGING SEQUENCE

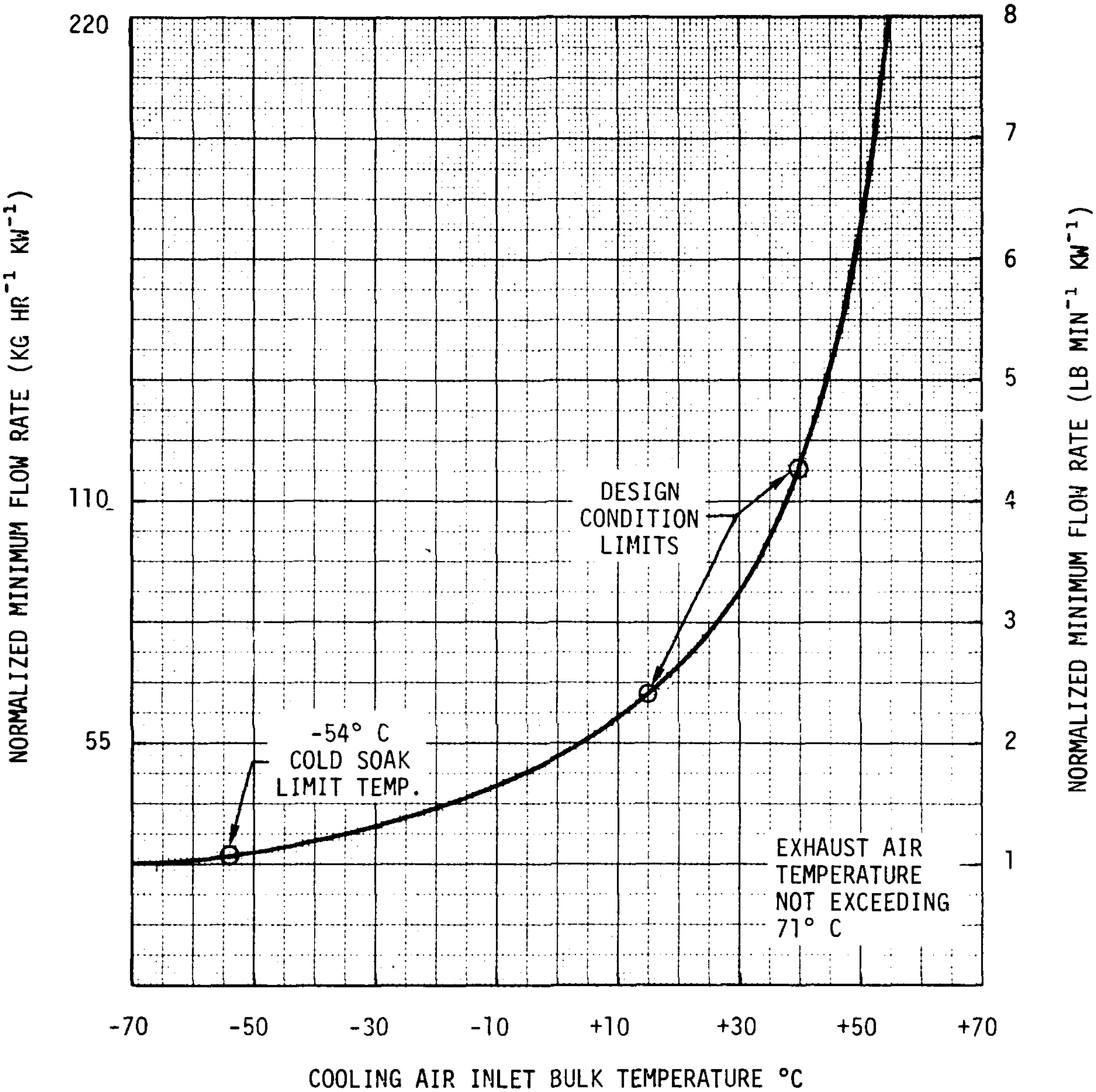


FIGURE 14 - COOLING AIRFLOW REQUIREMENTS

APPENDIX I

COOLING EVALUATION TEST

10.1 PURPOSE. This test is conducted on the LRU to determine:

(a) The total wattage input and actual heat dissipation for all modes of electrical operation.

(b) The temperature of equipment sidewalls at the thermal design condition.

(c) Pressure drop through the equipment versus coolant airflow rate.

(d) Temperature characteristics at the thermal design condition and other anticipated transient and abnormal environmental operating conditions

10.2 APPARATUS

The test apparatus, test equipment, instrumentation methods and accuracies used for this test shall follow the general guidance of MIL-STD-810.

10.2.1 Installation of Test Item in Test Facility. The test chamber installation shall be designed to be representative of aircraft avionics bay conditions. The cooling air (where applicable) shall be separately controlled, and shall be supplied through fully representative inlet ducting and LRU exhaust conditions. Heat sources representing adjacent avionics LRUs shall be included.

10.2.2 Measurements for Cooling Evaluation Test. Instrumentation shall be provided to measure the following items, as applicable, during testing:

(a) Test Chamber Instrumentation

Ambient temperature external to the test chamber.

Bulk temperature of the coolant entering the test chamber ducting.

Ambient temperature surrounding the LRU under evaluation

External surface temperatures of the LRU under evaluation; viz., front, top, bottom, and sides. (Measurement to be representative of the average surface temperature. Several measurements may be required on a surface where gradients exist.)

Temperatures of surfaces facing the test unit.

Power input of simulated LRUs, as applicable.

Bulk temperature of the coolant exiting the unit.

Ambient pressure external to the test chamber.

Chamber pressure external to the LRU under evaluation.

(b) Thermal Instrumentation Internal to the LRU Under Evaluation
Temperature measurements internal to the LRU shall include as a minimum the following:

The three highest-power dissipating components in each of the three highest power dissipating subassemblies.

The three most temperature-critical components in the LRU.

The three hottest components of each type:

resistors
capacitors
transformers
power devices, etc.

The three components with the largest thermal inertia.

The three components in the LRU that are subject to the highest electrical stress ratio.

Each component that dissipates 1% or more of the LRU's input power.

Each special device:

overtemperature indicator
heat sinks
heat exchanger interfaces, etc.

(c) LRU Functional Measurements

Differential pressure, total to total (in mm of water) from the test unit coolant inlet to outlet. Determine using a separate pressure drop test setup. The pressure drop shall not include the drop across the metering orifice or other miscellaneous losses, external to the LRU.

Bulk temperature of the coolant entering the test unit.

Mass flow rate of the coolant through the test unit.

Test unit's heat dissipation. (Equal to power input to the test unit minus power output from the test unit not dissipated as heat.)

Test unit's functional performance characteristics.

10.3 TEST REPORT. The test report will contain the details and results of the cooling evaluation test. The data shall include the actual test sequence used, and test conditions and results recorded as required during the test.

The test data shall include a complete description of all test equipment and accessories. The test apparatus shall be adequately documented by photographs, schematics, or line drawings. All stimulus and measurement equipment shall be identified by make and model and the latest calibration date recorded.

10.4 TESTS REQUIRED.

Step (1) Heat Dissipation. Measure the total wattage input and determine the actual heat dissipation in watts for all modes of electrical operation for which the equipment was designed; e.g., standby, receiving, transmitting, etc. These measurements are to be made at the laboratory ambient temperature which shall be recorded.

Identify the electrical operating mode corresponding to maximum steady-state heat dissipation (see Paragraph 3.10).

Step (2) Coolant Pressure Drop Through LRU Versus Flow Rate. Measure ΔP_s at 15.5°C and the rated flow per 5.1.2.1.

Step (3) Normal Continuous Operation (Thermal Design Conditions). With the test unit operating at maximum steady-state heat dissipation, stabilize the equipment at the conditions

(a) Sea level, 71°C ambient temperature, inlet cooling air at 40°C.

(b) Maximum altitude and ambient temperature, per Figure 4, inlet cooling air at 40°C.

(c) Sea level - 54°C ambient, -54°C cooling air

Step (4) <u>Transient Thermal Environments</u>. From stabilized -54°C non-operational soak to stabilized 71°C ambient 40°C cooling air inlet operation at maximum steady-state heat dissipation. Then shut off cooling air flow for 10 minutes. Restore cooling air flow at 40°C and restabilize all conditions before transition to -54°C ambient and -54°C cooling air temperatures.

Step (5) <u>Abnormal Flow Conditions</u>. TBD (per 5.1.4)

APPENDIX II

MECHANICAL EVALUATION TESTS

11.1 Purpose. This testing is performed to assure that when an LRU reaches formal qualification, high confidence exists that design deficiencies have been eliminated. This will minimize delay and cost of qualification failures and subsequent production slip or retrofit.

11.2 Program. A program will be developed containing a series of tests integrated into LRU development. Tests will be designed and scheduled to provide design feedback information and will be conducted as early as possible and throughout LRU development. MIL-STD-810 will be used as a baseline for test techniques, procedures, tolerances, and data reduction. Test criteria will be tailored to specific test objectives.

Commentary: Testing should be primarily wideband random vibration. However, acoustic noise, narrowband random vibration, sinusoidal vibration, shock, or acceleration (steady load) may be used as diagnostic tools or for specific objectives. Tests should be conducted on selected specimens from component, subassembly, brassboard, engineering model, and preproduction hardware. Tests should be designed to provide diagnostic information and to evaluate performance and life under stress. In general, both goals should be pursued in each test but sometimes more limited objectives are appropriate. Diagnostic information would include such things as vibration mode shape, frequencies and damping, relative motions between structures, subassemblies, or components, and static deflections of structures. Special attention should be given to assuring that chassis, subassembly, and component resonant frequencies are separated to minimize amplification of input motions. This is important to avoid problems due to transient loads and vibration. A recommended method of evaluation under stress is to progressively increase test severity until failure occurs and/or performance deteriorates. Testing to failure is not always practical because of hardware availability; however, failure data is very useful and should be obtained when possible.

Determination of resonant frequencies, mode shapes, and damping are key elements in conducting and utilizing results of dynamic tests. Resonances can be detected visually (strobe light), by sound (changes in level and pitch), and with instrumentation (accelerometers, velocity pickups, microphones, proximity pickups). Detection of motions inside closed equipment will be necessary. This may involve covers with windows or holes, or covers removed (where structural response is not significantly changed) as well as instrumentation.

11.3 Report. The report will contain a summary of the mechanical evaluation test program and will show through program results that the LRU is ready for qualification. It will also include test hardware descriptions, test criteria, and summaries of data and failure analyses for each test.